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ON THE VELOCITY WITH WHICH METEORS ENTER THE EARTH'S ATMOSPHERE.

BY PERCIVAL LOWELL.

On page 380 of MOULTON's interesting "Introduction to Astronomy" there is a statement in celestial mechanics with regard to meteors of sufficient importance to be revised, which I noticed in reading the book, and the more so that the problem there presented permits of solution by a method of great value, the use of which it serves to illustrate, that of rotating a field of force.

Mr. MOULTON says: — "Let us assume provisionally that the meteors are moving around the sun in sensibly parabolic orbits, like the orbits of the comets, and let us find the greatest and least velocities with which they can encounter the earth's atmosphere. If it were not for the earth's attraction they would pass the earth's orbit at the rate of twenty-five miles per second, the velocity being independent of the angle at which they crossed. The earth's attraction would generate a velocity of nearly seven miles per second in a body falling from an infinite distance into its atmosphere, whether the sun were attracting it or not. The greatest relative velocity will be when the earth and meteor meet, which is 25+7+18=50 miles per second. The least will be when the meteor overtakes the earth, which is 25 + 7 − 18 = 14 miles per second."

Now the velocities due to the Sun's attraction and to the earth's upon a particle falling to the latter under the action of both cannot be added in this simple manner.

To solve the problem we shall make use of a rotating field of force.

Consider a system of axes ξ, η, ζ, of which ξ and η rotate about ζ with a uniform angular spin n. Take the origin at the Sun, and let the ξ axis continually pass through the earth supposed to travel in a circle. Then the space velocities u, v and w expressed in the moving axes ξ, η and ζ respectively, or the space rates of change of ξ, η, ζ are

$$\begin{aligned} u &= \xi' - n\eta \\ v &= \eta' + n\xi \\ w &= \zeta' \end{aligned}$$

where the accents denote the derivatives with respect to the time. Similarly the accelerations or the forces which they measure, X, Y and Z expressed in the same axes are

$$\begin{aligned} X &= u' - nv \\ Y &= v' - nu \\ Z &= w' \end{aligned}$$

Substituting for u, v and n in the last equations their values from the first we have

$$\begin{aligned} \frac{d^2\xi}{dt^2} - 2n\frac{d\eta}{dt} - n^2\xi &= X \\ \frac{d^2\eta}{dt^2} + 2n\frac{d\xi}{dt} - n^2\eta &= Y \\ \frac{d^2\zeta}{dt^2} &= Z \end{aligned}$$

Let U be the potential of the forces,

$$\frac{dU}{d\xi} = X,\quad \frac{dU}{d\eta} = Y \text{ and } \frac{dU}{d\zeta} = Z$$

In the rotating field of force U is a function of ξ, η and ζ only, since the time has been eliminated by the rotation. Therefore

$$\frac{dU}{dt} = \frac{dU}{d\xi}\cdot\frac{d\xi}{dt} + \frac{dU}{d\eta}\cdot\frac{d\eta}{dt} + \frac{dU}{d\zeta}\cdot\frac{d\zeta}{dt}$$

If the equations of motion be multiplied by

$$2\frac{d\xi}{dt},\ 2\frac{d\eta}{dt} \text{ and } 2\frac{d\zeta}{dt}$$

respectively, and added, they admit of an integral first found by JACOBI

$$v_1^2 - n^2r^2 = 2U + C$$

in which v_1 = velocity of the particle relatively to the moving axes, its relative not its space rate.

and r = its distance from the origin reckoned by the same.

We shall suppose the particle to be moving in the plane of the planet's motion, that of ξ, η. The velocity of encounter with the planet is thus made the greatest or the least possible, according as the particle overtakes the planet or meets it head on.

Calling V the space velocity of the particle, that is the velocity with regard to fixed axes, and A the moment of momentum with regard to the same at the moment, we have

$$V^2 = v_1^2 - 2nr\cos\alpha v_1 + n^2r^2$$

in which α is the angle between v_1, and nr — hence $r\cos\alpha = p_1$, the perpendicular from the origin upon the particle's line of motion in space, but $A = v_1p + nr^2$ by taking moments about the origin, of the particle's motion in the rotating plane plus that of the plane itself,

$$\therefore\ v_1^2 - n^2r^2 = V^2 - 2nA$$

whence

$$V^2 - 2nA = 2U + C$$

We determine C by the consideration that for a parabola at infinity,

$$V = 0 \text{ and } U = 0$$

whence — since $n = \dfrac{\sqrt{M}}{c^{\frac{3}{2}}}$ and $A = \sqrt{M+m}\,.\,\sqrt{l}$

$$C = -2nA = -\frac{2\sqrt{M}\,.\sqrt{M+m}\sqrt{l}}{c^{\frac{3}{2}}}$$

where l is the parameter of the parabola and c the radius of the planet's orbit.

Suppose now the particle to be just overtaking the planet from behind, l will very approximately be $2r$, while

$$A = v_1p + nr^2 \text{ will}$$
$$= V - v_0\,.\,p + nr^2$$ in which v_0 is the velocity of the planet in its orbit,

then $v_0p = nr^2$

and $A = r\,.\,V$

$2nA = 2nr\,.\,V$

Let M = mass of the sun

m = mass of the planet

$r = c$ = radius of the planet's orbit

ρ = distance from the earth's centre to where the meteor enters the atmosphere, which for round numbers we may take at 3958.8 + 41 miles or 4,000 miles.

Then the attraction of the sun on the particle is

$$-\frac{M}{r^2} \text{ very approximately}$$

that of the planet on the particle

$$-\frac{m}{\rho^2}$$

and that of the planet on the sun which is to be applied reversed to bring the sun to rest

$$-\frac{m}{r^2}.$$

This latter force acts only in the line ξ.

Consequently, since X and Y are functions of ξ and η only, not involving t

$$U = \frac{M}{r} + \frac{m}{\rho} - \frac{m\xi}{r^2}\,;\quad \frac{dU}{d\xi}\,d\xi = X d\xi,\ \frac{dU}{d\eta}\,d\eta = Y d\eta$$

our equation becomes

$$V^2 - 2nrV = 2\left(\frac{M}{r} + \frac{m}{\rho} - \frac{m\xi}{r^2}\right) - 2\,\frac{\sqrt{M}\sqrt{M+m}\sqrt{2r}}{r^{\frac{3}{2}}}$$

Completing the square on the right-hand side and extracting the square root we have

$$V = +nr \pm \sqrt{2\left(\frac{M}{r} + \frac{m}{\rho} - \frac{m\xi}{r^2}\right) - 2\,\frac{\sqrt{M}\sqrt{M+m}\sqrt{2r}}{r^{\frac{3}{2}}} + n^2r^2}$$

Letting $M = 1$ and $r = 1$ and determining k, the coefficient of proportionality so that V comes out in miles per second, — for k enters with the masses as k^2M unless the unit of time be canonically chosen, we find, since $v_0 = nr$,

$V - v_0$ = the velocity relative to the earth
= 10.321 miles a second when the particle overtakes the earth.

The earth's effect in increasing the velocity which in this case is the greatest possible is

28.822 − 26.163 = 2.659 miles a second.

In the other case when the earth encounters the particle head on, v_1 becomes negative and C negative

$$A = -v_1p + nr^2$$
$$= -(V + v_0)\,p + nr^2$$
$$-2nA = +2nrV$$

and

$$V^2 + 2nrV = 2\left(\frac{M}{r} + \frac{m}{\rho} - \frac{m\xi}{r^2}\right) + 2\,\frac{\sqrt{M}\sqrt{M+m}\sqrt{2r}}{r^{\frac{3}{2}}}$$

and

$$V = -nr \pm \sqrt{2\left(\frac{M}{r} + \frac{m}{\rho} - \frac{m\xi}{r^2}\right) + 2\,\frac{\sqrt{M}\sqrt{M+m}\sqrt{2r}}{r^{\frac{3}{2}}} + n^2r^2}$$

whence $V + v_0$ = 45.197 miles a second, and the effect of the earth in increasing the meteor's velocity

= 26.696 − 26.163 = 0.533 miles a second.

The geometric explanation why the velocities cannot be directly added is that when each body is supposed to act alone the times involved in their actions are different while when they act together these are naturally the same. In the latter case the velocity due the sun hurries the particle through the space faster than the earth's pull alone could and so gives the earth less time to act.

Some interesting deductions follow from the above computation. Since the observed velocities of meteors entering the earth's atmosphere are all below the superior limit found it is evident that none reach us with hyperbolic velocity, if we make exclusion of the retardation due the air up to the time the meteor becomes visible through incandescence. That such retardation tends to be offset by the added velocity imparted by the earth makes this inference fair. On the other hand, we have no examples that I am aware of, of absolute overtaking in the earth's path. Still this is not vital as the earth's recession tends to increase the apparent angle which the meteor's flight makes with the earth's quit and in small angles the velocity of pursuit varies only as the cosine. We may, therefore, conclude that no meteors travel in hyperbolic orbits, and that, in consequence, they all belong to the system over which the sun holds sway.

CERTAIN TRAJECTORIES COMMON TO DIFFERENT LAWS OF CENTRAL FORCE,

BY FRANK LOXLEY GRIFFIN.

§1. It is usually overlooked* that the law of force under which a given curve is described as a central orbit with a given constant of areas, cannot be uniquely determined from a knowledge of the position of the center of force. For example, it is commonly (though erroneously) stated that, if a planet describe an ellipse as a central orbit, with the Sun at a focus, the law must be that of NEWTON. Again, students are given the polar equation of a curve (referred to the center of force), and are asked to find *the* law of force for which the curve is described as a central orbit; whereas, in fact, there is an infinitude of possible laws.

§2. A SPECIAL CASE.

Consider first, for the sake of clearness, the particular case of the KEPLERIAN ellipse. If h be the constant of areas, θ the longitude (measured from the pericenter), and u the reciprocal of the radius vector, the equation of an ellipse with its focus at the origin is:

$$u = \frac{1+e\cos\theta}{a(1-e^2)} \tag{1}$$

Now, as is well known, the required force, f, must vary along the orbit according to the equation:

$$f = h^2u^2\left(u+\frac{d^2u}{d\theta^2}\right) \tag{2}$$

Hence, at every point of the ellipse,

$$f = \frac{h^2u^2}{a(1-e^2)} = \frac{h^2}{a(1-e^2)}\cdot\frac{1}{r^2} \tag{3}$$

that is, the Newtonian law of force is admissible.

But, since (1) holds along the curve, f is given, at every point of the orbit, by the equation:

$$f = \frac{h^2}{a^3(1-e)^3}\cdot(1+e\cos\theta)^2 \tag{4}$$

which is another law of force, under which the given ellipse may be described. Still other laws may be obtained by employing equation (1) with the identity $u^2 = u^m u^{2-m}$, [or, indeed, in many other ways]; viz.:

$$f = K_m \,.\, u^{2-m}(1+e\cos\theta)^m \quad , \quad \text{where} \quad K_m = \frac{h^2}{a^{m+1}(1-e^2)^{m+1}} \tag{5}$$

Now, equation (1) is satisfied only at points of the ellipse. Hence, the various laws of (5), [which includes (3) and (4)], prescribe the same value for the force along the given orbit; but elsewhere they furnish distinct values, and are consequently distinct laws. *Which of these distinct laws (if any) characterizes the force which actually produces the observed motion, cannot be decided from the single orbit.* It can merely be stated that, of the infinitude (5) of admissible laws, that of NEWTON is the only one for which the force is a function of the distance alone. There is also but one law, viz.: (4), in which the force is a function of the direction alone.

§3. THE GENERAL CASE.

Consider now any curve $F(u, \theta) = 0$, which is described as a central orbit, the origin being taken at the center of force. The force must vary according to equation (2); but there is an infinitude of admissible laws.* For example, if, from the equation of the orbit, the right member of equation (2) is found as a function of u alone, one law is obtained; if as a function of θ alone, another law is obtained. *To go from either of these laws to another, it is merely necessary to substitute, from the equation of the given curve, for any function of either co-ordinate appearing in the expression for the force, an equivalent function of the other co-ordinate.*

All these laws prescribe, then, at every point of the given orbit, the same value for the force; but elsewhere they prescribe distinct values.

§4. OTHER TRAJECTORIES THAN THE ORIGINAL ORBIT.

It may be of interest to ascertain whether two distinct laws of the infinitude (5) can have in common any orbits

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*Cf., however, P. APPELL: *Traité de Mécanique Rationnelle*, V. I, p. 363.

*Cf. P. APPELL, loc. cit.

other than the original ellipse; and, if so, the properties which such common trajectories must possess. In particular, would any of those laws, save that of NEWTON, admit so great a variety of elliptical orbits as is found in the solar system? The following facts will be established.

(I) Every law of the infinitude (5), except the Newtonian, admits a single infinitude of elliptical orbits, one of whose foci is at the center of force. These ellipses all have the same eccentricity, and have their major axes in the same straight line. There is, of course, just one constant of areas for each orbit.

(II) This infinitude of elliptical orbits is common to all laws of the infinitude (5); the constant of areas for any given orbit depends upon the law selected.

To prove these statements, consider the equation of any ellipse in the plane, which has one focus at the center of force:

$$u = \frac{1+E\cos(\theta-\alpha)}{A(1-E^2)} \tag{6}$$

where A is the major semi-axis, E, the eccentricity, and α, the longitude of the peri-center. Evidently, for $E = e$, $A = a$, and $\alpha = 0$, the curve is the original ellipse. If the ellipse (6) is described with the constant of areas, H, the law of force may be:

$$f = K_M \,.\, u^{2-M}(1+E\cos(\theta-\alpha))^M \;, \quad K_M = \frac{H^2}{A^{M+1}(1-E^2)^{M+1}} \tag{7}$$

where M is arbitrary. But if this law is to be the same as a law of (5), evidently:

$$K_M u^{2-M}(1+E\cos(\theta-\alpha))^M \equiv K_m u^{2-m}(1+e\cos\theta)^m \tag{8}$$

for all real values ($u > 0$) of θ, and u. Now if $M \neq m$, then, by taking u sufficiently large, one of the quantities $1+e\cos\theta$, $1+E\cos(\theta-\alpha)$ can be made larger than any assigned value, which is impossible. Hence, $M = m$; and [except for $m = 0$, NEWTON'S Law],

$$\frac{H^{\frac{2}{m}}}{A^{\frac{m+1}{m}}(1-E^2)^{\frac{m+1}{m}}}(1+E\cos(\theta-\alpha)) \equiv \frac{h^{\frac{2}{m}}}{a^{\frac{m+1}{m}}(1-e^2)^{\frac{m+1}{m}}}(1+e\cos\theta) \tag{9}$$

Therefore, by differentiation:

$$\frac{H^{\frac{2}{m}}E}{A^{\frac{m+1}{m}}(1-E^2)^{\frac{m+1}{m}}}\sin(\theta-\alpha) \equiv \frac{h^{\frac{2}{m}}.\,e}{a^{\frac{m+1}{m}}(1-e^2)^{\frac{m+1}{m}}}\sin\theta \tag{10}$$

and, since $e \neq 0$, (10) gives, for $\theta = \alpha$, $\sin\alpha = 0$, or $\alpha = 0, \pi$. That is, any ellipse described under any law of (5) has its major axis in the same straight line as that of the original ellipse. Again, since $\alpha = 0, \pi$, (9) gives for

$$\theta = \frac{\pi}{2}\,, \qquad \frac{H^{\frac{2}{m+1}}}{A(1-E^2)} = \frac{h^{\frac{2}{m+1}}}{a(1-e^2)}$$

Hence (10) gives $E = \pm e$ according as $\alpha = 0$ or π. But E and e are essentially positive, which shows that $\alpha = 0$ and $E = e$. Thus α and E are determined; but A still remains arbitrary; consequently, there is a single infinitude of possible elliptical orbits, the constant of areas for each being determined by

$$H = h\,.\left(\frac{A}{a}\right)^{\frac{m+1}{2}} \tag{11}$$

Williams College, 1907 October.

Thus the statements of (I) are established.

Consider next any two laws of the infinitude (5), viz.: for $m = \mu$ and $m = \mu'$, and any one of the infinitude of elliptical orbits admitted by the former, viz.:

$$u = \frac{1+e\cos\theta}{A(1-e^2)} \tag{12}$$

The proof of (I) above that (12) is admissible for some law of (5) did not restrict m, and the parameters of this ellipse are independent of m; hence this orbit is admitted also by the latter law. The constants of areas in the two cases, however, will generally differ, being determined from (11):

$$H_\mu = h\,.\left(\frac{A}{a}\right)^{\frac{\mu+1}{2}} \;, \quad H_{\mu'} = h\,.\left(\frac{A}{a}\right)^{\frac{\mu'+1}{2}} \tag{13}$$

It may be remarked in conclusion that, while the infinitude (5) admits elliptic orbits of some generality, it admits none whose pericenters have distinct longitudes, as in the solar system.

OBSERVATIONS OF THE TRANSIT OF *MERCURY*, NOVEMBER 14, 1907.

By ROBERT W. WILLSON.

The egress of the planet was watched here with the $7\frac{1}{2}$-inch Clark equatorial using an unsilvered prism, neutral tint wedge and a power of 100. The coordinates of the place of observation are $\varphi = +42^\circ\,22'\,38''$, $\varphi' = +42^\circ\,11'\,1''$, $\lambda = 4^h\,44^m\,28^s.84$, $\log\rho = 9.9993$, whence the Greenwich Mean Times of the third and fourth contacts computed by the formula of the American Ephemeris are $4^h\,18^m\,18^s.7$ and $4^h\,50^m\,57^s.5$, respectively.

My observations were:

Gr. M.T.	$1^{h}\ 48^{m}\ 11^{s}$	Black drop
	1 48 30	Contact
	1 49 39	Bisected
	1 50 55	Surely off

The first contact was extremely sharp, the ligament appearing suddenly as a very fine line and widening for about two seconds, when it was blurred by a wave of poor definition, but soon reappeared as a strong black line, and increased continually until the second observation, which was noted when the distance of the inner limb of the planet from the sun's limb was estimated equal to the diameter of the planet parallel to the sun's limb.

Very soon the planet took the form of a semi-circle resting on a rectangle whose base equalled the planet's diameter, exactly resembling the figure described by Sir William Huggins at the transit of Nov. 5, 1868.*

The height of the rectangle decreased until the time of the third observations, when the shape was exactly semicircular. The time of this phase seemed to be determinate within three seconds.

As my note indicates, the time of the last contact was probably late, the boiling of sun's limb being considerable. The image of the planet was well defined though unsteady, and the observations were much more satisfactory than at the transits of *Mercury* in 1878, and of *Venus* in 1882, which I observed at much greater altitudes but with smaller instruments. The formation of the ligament was as startling and definite a phenomenon as the occultation of a star.

Mr. Dunham Jackson, who observed near me with a four-inch Clark equatorial, with Herschel prism and red shade, power 60, without clock-work, noted the third and fourth contacts at $1^{h}\ 48^{m}\ 21^{s}$ and $1^{h}\ 50^{m}\ 25^{s}$ respectively. I suppose our differences are not excessive in consideration of the difference of instrumental power.

Harvard University, Students' Astronomical Laboratory.

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* *M.N.* xxix, p. 27, reproduced in *Chambers' Astronomy*, 4th ed., I, p. 343.

RESULTS OF OBSERVATIONS OF THE TRANSIT OF *MERCURY*,

MADE AT THE U. S. NAVAL OBSERVATORY,

By W. S. EICHELBERGER.

[Communicated by the Superintendent.]

The transit of *Mercury*, occurring on the morning of Nov. 14, 1907, was observed visually at four instruments by Prof. W. S. Eichelberger, Assistant Astronomers G. A. Hill and J. C. Hammond, and Assistant Matt Frederickson, as follows:

Date	Washington III Contact	Mean Time IV Contact	Instrument	Effect. aperture	Power of eye-piece
	h m s	h m s			
Nov. 13	20 40 1	20 42 33	12″ equat.	4	120[1]
	20 39 49	20 42 29	5″ equat.	5	75[2]
	20 39 48	20 42 11	5″ comet seeker	3	60[3]
	20 39 51	20 42 21	4″ finder of 12″ equat.	2	35[4]

Obs.—[1] Hammond. [2] Hill. [3] Frederickson, [4] Eichelberger.

NOTES:

Mr. Hill: At times a grayish illumination would come over the planet when it was about two of its diameters from the Sun's limb.

$20^{h}\ 0^{m}$. Illumination of grayish color on following side of *Mercury*.

$20^{h}\ 5^{m}$. Illumination still remains on following side.

$20^{h}\ 20^{m}$. When the telescope is moved back and forth a fringe of grayish color comes out on preceding side.

When the preceding half of Mercury was off the Sun's disk, that part showed no illumination, nor could it be seen at all. Seeing unsteady. A diagonal, solar eyepiece, with shade-glass, was used.

Mr. Hammond: The time of third contact is that of estimated geometrical contact and is about 10 seconds after the black drop was seen to form.

While on the Sun's disk, *Mercury* continually appeared as a dark, opaque body of uniform tint. No part of the disk of *Mercury* that projected beyond the Sun's limb was visible at any time between third and fourth contacts. Seeing unsteady. A polarizing eye-piece was used, without dark shade-glass.

Mr. Frederickson: The comet seeker is of the broken back type and of an alt-azimuth mounting.

The time of third contact is that of the formation of the black drop. No part of the disk of *Mercury* that projected beyond the Sun's limb was visible at any time between third and fourth contacts, nor could any luminous band surrounding the planet be seen after third contact. Seeing unsteady. A direct eye-piece with shade-glass was used.

In addition to these visual observations, Assistant G. H. Peters obtained twelve photographs of the transit with the 40-foot photoheliograph. He was assisted in this work by Dr. G. F. Coulon.

OBSERVATIONS OF VARIABLE STARS.—No. 10.

By WM. E. SPERRA.

294. *W Cassiopeae.*

Fifteen observations of this star, extending from 1907 July 12 to 1907 Nov. 12, give as the date of maximum 1907 Aug. 25, at 8^{M}.9. At first observation the star was of 9^{M}.2, and at the last had fallen to 9^{M}.8. Several observations deviate widely from the curve as drawn; one for Aug. 18, at 8^{M}.5, and five others following the maximum date seem to indicate a secondary crest about Oct. 10, at 9^{M}.0, after having reached 9^{M}.2, Sept. 26. However, no weight was given this secondary maximum, and a smoothed curve was drawn through the series.

4521. *R Virginis.*

A minimum at 10^{M}.7, for 1907 June 14, is indicated from seventeen observations extending from 1907 May 9 to 1907 July 26. At first observation the star's light was 8^{M}.2, and at the last was 8^{M}.9. The plotted observations are very close to the smoothed curve.

4557. *S Ursae Majoris.*

Twenty-five observations of this star, from 1907 May 1, at 9^{M}.2, to 1907 Aug. 18, at 9^{M}.3, give as the date of maximum 1907 June 30, at 7^{M}.7. The rise was slower than the decline, though the curve above 8^{M}.5 is very symmetrical with regard to both branches, rather flat for a month preceding and following maximum. All observations are well represented by the curve.

4816. *U Virginis.*

A maximum for 1907 May 31, at 8^{M}.6, is indicated from twenty observations, extending from 1907 May 9, at 8^{M}.8, to 1907 July 12, at 9^{M}.1. Considerable deviation from a smooth curve exists, especially near maximum.

5157. *S Bootis.*

Twenty observations of this star, from 1907 June 15, at 9^{M}.6, to 1907 Sept. 30, at 9^{M}.7, yield as the date of maximum 1907 Aug. 6, at 8^{M}.7. While considerable deviation from a smooth curve exists near its crest, the maximum is well defined.

5237. *R Bootis.*

A well defined maximum of this star is indicated for 1907 May 16, at 7^{M}.5, from a series of twenty observations from 1907 April 21, at 8^{M}.6, to 1907 June 30, at 9^{M}.0. The decline was quite slow for three weeks after maximum.

6207. *Z Ophiuchi.*

A series of twenty-three observations, extending from 1907 July 2, at 10^{M}.3, to 1907 Nov. 12, when the star had declined to 8^{M}.0, indicate as the date of maximum 1907 Sept. 21, at 7^{M}.5. The rise was very rapid till the last days of July when 8^{M}.5 was reached, a retardation then set in and while the rise continued steady, the next month was required to reach 7^{M}.5, or maximum light, the next five weeks its light was nearly stationary at this magnitude, and the first week in October the decline set in.

7085. *RT Cygni.*

Twenty-seven observations of this star, commencing when at 8^{M}.7, 1907 May 2, and extending to 1907 Aug. 4, when 9^{M}.0 was reached on the decline, yield as the date of maximum 1907 June 7, at 6^{M}.3. The curve resembles that of *Z Ophiuchi*, as does also that of *R Bootis*, except in the case of the first and last mentioned stars, the light changes were twice as rapid as in the case of *Z Ophiuchi*. In the case of *RT Cygni* the retardation in rise occurred at 7^{M}.3, about May 14, and in two weeks 6^{M}.3 was reached; little change then occurred for two more weeks, or about June 15, when the decline set in, slow at first and then more rapid.

4805. *W Virginis.*

Twenty-six observations of this star, from 1907 May to 1907 July 14, yield three maxima and two minima, as follows:

			M	
Minimum	1907	May 12.5	10.0	Good
Maximum		May 18.6	9.0	Fairly good
Maximum		June 7.0	8.9	Good
Minimum		July 3.5	9.9	Somewhat uncertain
Maximum		July 10.7	8.9	Somewhat uncertain

2815. *U Geminorum.*

		M
1907 April	19.61	9.68
	20.56	9.73
	21.57	9.73
	22.56	9.70
	26.57	9.83

5484. *U Coronae.*

1907 May 11, eleven observations, from 13^{h} 49^{m} to 19^{h} 34^{m} G.M.T. The decline was not very well observed.

	h	m
Greenwich Time of minimum by single curve.	15	37
Greenwich Time of minimum by mean curve.	16	6
Greenwich Time of minimum by equal lights.	16	17.0

Mag.	Before		After		Mean	
	h	m	h	m	h	m
8.1	13	47	19	34	16	40.5
8.3	13	53	18	57	16	25.0
8.5	13	59	18	20	16	9.5
8.7	14	13	17	32	15	52.5
Mean (Greenwich M.T.)					16	17.–

Lowest observed light 8^{M}.9

Cleveland, Ohio, 1908 Jan. 5.

DEFINITIVE ORBIT OF COMET 1813 I.

By HENRY A. PECK.

In *Astronomische Nachrichten* 4205, Holetschek has called attention to the fact that the orbits of Comet 1813 I. as given by both Werner and Nicollet, are affected by a systematic error, and that the longitude of the ascending node and the distance from the perihelion to the node should be increased by 180°. About two years ago I began the computation of the definitive orbit of this comet and at once discovered this same source of error in attempting a trial ephemeris from the published elements. The observations seemed so discordant that the work was laid aside in the hope that by correspondence material for a new reduction might be found. I find myself still in the same position but have thought it advisable to publish the results, especially as they confirm the orbit given by Werner when it has been corrected in the manner noted by Holetschek. The comet was discovered by Pons, on February fourth, and was observed by him until the eleventh of March. The Paris Observatory began a series of observations on the eighteenth of February, which was terminated on the seventh of the following month. The Pons observations are published in the twenty-seventh volume of Von Zach's *Monatliche Correspondenz*. As no data are given by which they can be corrected, it has been necessary to use them as they stand. The Paris observations are contained in the first volume of the *Obs. Astr. de Paris*. In reducing them no attention has been paid to the differential refraction, as the error arising from this source is quite insignificant in comparison to that which comes from the unsatisfactory state of the observations of Pons. It has been thought best to give the ephemeris of both the sun and comet in full, as it will enable any newly discovered observations to be utilized at a minimum of effort.

The ephemeris of the sun is based on Newcomb's tables of the sun, and is as follows:

		Long. of ⊙			Sidereal Time			log *R*	Lat. of ⊙
		°	′	″	h	m	s		″
Feb.	3	314	21	37.2	20	53	6.35	9.993928	−0.36
	4	315	22	26.3		57	2.90	3999	48
	5	316	23	13.9	21	0	59.46	4072	58
	6	317	24	00.0		4	56.01	4147	65
	7	318	24	44.4		8	52.57	4223	69
	8	319	25	27.3		21	49.12	4300	70
	9	320	26	8.5		16	45.68	4379	69
	10	321	26	47.9		20	42.24	4460	63
	11	322	27	25.7		24	38.79	4541	55
	12	323	28	1.5		28	35.35	4629	44
	13	324	28	36.2		32	31.90	4716	30
	14	325	29	9.0		36	28.46	4805	17
	15	326	29	40.2		40	25.01	4897	−0.04
	16	327	30	10.0		44	21.57	4990	+0.08
	17	328	30	38.2	21	48	18.12	9.995086	+0.20
Feb.	18	329	31	4.1	21	52	14.68	9.995184	+0.30
	19	330	31	31.1	21	56	11.23	5283	38
	20	331	31	53.9	22	0	7.79	5385	44
	21	332	32	16.3		4	4.34	5488	47
	22	333	32	37.2		8	0.90	5592	47
	23	334	32	56.7		11	57.45	5698	44
	24	335	33	14.7		15	54.01	5805	40
	25	336	33	31.2		19	50.57	5913	33
	26	337	33	46.3		23	47.12	6022	23
	27	338	33	59.8		27	43.68	6132	+0 11
	28	339	34	11.6		31	40.23	6243	−0.01
Mar.	1	340	34	21.7		35	36.79	6354	15
	2	341	34	30.2		39	33.34	6466	28
	3	342	34	36.8		43	29.90	6578	40
	4	343	34	41.5		47	26.45	6690	49
	5	344	34	44.3		51	23.01	6803	57
	6	345	34	44.8		55	19.56	6916	62
	7	346	34	43.3	22	59	16.12	7030	64
	8	347	34	39.7	23	3	12.67	7144	63
	9	348	34	33.5		7	9.23	7258	57
	10	349	34	25.3		11	5.79	7374	50
	11	350	34	14.7		15	2.34	7490	40
	12	351	34	2.0		18	58.90	9.997607	−0.27

Obliquity of the ecliptic = 23° 27′ 49″.03.

From this the solar coordinates, referred to the mean equinox and equator of 1813.0, are:

		X	*Y*	*Z*
Feb.	3	+0.689462	−0.646733	−0.280718
	4	701940	635548	275863
	5	714202	624166	270921
	6	726243	612593	265899
	7	738057	600833	260793
	8	749642	588889	255609
	9	760995	576763	250345
	10	772115	564461	245046
	11	782997	551989	239593
	12	793638	539350	234109
	13	804036	526545	228550
	14	814188	513579	222921
	15	824092	500457	217227
	16	833744	487182	211465
	17	873142	473759	205639
	18	852284	460193	199751
	19	861168	446484	193799
	20	869790	432638	187792
	21	878146	418660	181724
	22	886234	404552	175600
	23	894054	390320	169423
	24	901602	375968	163193
	25	908874	361499	156912
	26	915872	346919	150584
	27	922590	332234	144207
	28	929026	317444	137789
Mar.	1	935180	302557	131327
	2	+0.941048	−0.287578	−0.124825

	X	Y	Z
Mar. 3	+0.946631	−0.272511	−0.118284
4	951924	257361	111708
5	956927	242132	105098
6	961640	226833	098456
7	966062	211465	091785
8	970188	196034	085087
9	974018	180547	078365
10	977560	165005	071620
11	980804	149417	064854
12	+0.983755	−0.133781	−0.058068

The constants for the reduction from mean to apparant position are:

	f ″	$g \cos G$ ″	$g \sin G$ ″	H ° ′	$\log h$	i ″
Feb. 3	−4.9	−2.09	+7.08	317 39	1.2933	−5.8
8	4.3	1.85	6.98	312 34	1.2900	6.2
13	3.8	1.61	6.86	307 26	1.2867	6.6
18	3.3	1.40	6.73	302 13	1.2836	7.0
23	2.7	1.19	6.63	296 56	1.2808	7.4
28	2.3	1.00	6.53	291 36	1.2784	7.6
Mar. 5	1.9	0.82	6.43	286 13	1.2765	7.8
10	−1.5	−0.64	+6.35	280 50	1.2750	−8.0

The following elements were made the basis of the comet ephemeris:

ELEMENTS.

T = March 4.53123 G.M.T.

$$\left.\begin{aligned} \omega &= 170^\circ\ 37'\ 22'' \\ \Omega &= 240\ \ 35\ \ 21 \\ i &= 158\ \ 53\ \ 16 \end{aligned}\right\}\ 1813.0$$

$\log q = 9.844580$

EQUATORIAL COORDINATES.

$$x = 9.977493\, r \sin(\ 21^\circ\ 45'\ 59''.9 + v)$$
$$y = 9.927204\, r \sin(\ 99\ \ 43\ \ 44.8 + v)$$
$$z = 9.791761\, r \sin(136\ \ 32\ \ 58.9 + v)$$
$$\log m = 0.193258$$

It will be noticed that if a correction of 180° be given the longitude of the ascending node as well as the argument of the perihelion, these elements are very similar to those given by WERNER in *Monatliche Correspondenz* XXVII, page 570. From them is derived the following ephemeris for the comet:

	α app. ° ′ ″	δ app. ° ′ ″	log r	log Δ	Ab'n. time Units 5th pl.
Feb. 3	322 18 21	+51 32 9	9.9619	9.5450	203
4	331 9 30	48 59 56	9560	5610	212
5	338 27 25	46 6 47	9502	5809	221
6	341 23 40	+43 7 16	9.9111	9.6035	233
Feb. 7	349 13 3	+40 11 12	9.9386	9.6279	246
8	353 9 26	37 24 4	9328	6532	261
9	356 24 10	34 48 37	9272	6789	276
10	359 6 9	32 25 40	9215	7047	293
11	1 22 11	30 15 1	9160	7300	310
12	3 17 26	28 15 57	9106	7548	328
13	4 55 55	26 27 29	9052	7789	347
14	6 20 41	24 48 31	9000	8022	367
15	7 34 4	23 18 00	8949	8246	387
16	8 37 58	21 55 0	8899	8462	406
17	9 33 52	20 38 39	8852	8671	426
18	10 22 56	19 28 11	8806	8869	445
19	11 6 8	18 22 53	8762	9061	465
20	44 17	17 22 11	8720	9245	485
21	12 18 1	16 25 33	8680	9422	505
22	47 52	15 32 32	8643	9591	525
23	13 14 18	14 42 45	8609	9751	545
24	37 42	13 55 50	8578	9.9908	565
25	58 24	11 30	8549	0.0058	585
26	14 16 41	12 29 29	8524	0202	604
27	32 47	11 49 34	8502	0339	624
28	46 56	11 32	8484	0471	643
Mar. 1	59 19	10 35 14	8469	0600	663
2	15 10 6	0 29	8458	0719	682
3	19 26	9 27 11	8450	0838	701
4	27 28	8 55 11	8446	0954	720
5	34 19	24 23	8446	1056	739
6	40 5	7 54 43	8450	1158	755
7	44 52	26 4	8457	1257	772
8	48 47	6 58 23	8468	1353	789
9	51 56	31 36	8483	1444	806
10	54 21	5 40	8501	1531	823
11	56 7	5 40 31	8523	1614	839
12	15 57 19	+ 5 16 6	9.8548	0.1693	856

The Paris observations depend on the following stars, which are all contained in the Berlin and Leipzig sections of the A. G. Catalog:

	α 1813.0 h m s	δ 1813.0 ° ′ ″
1	0 44 42.41	+18 10 19.5
2	55 14.05	13 56 13.1
3	56 11.34	11 57 2.4
4	57 8.76	19 8 51.5
5	58 36.04	8 51 22.8
6	0 59 50.51	18 39 27.4
7	1 1 7.62	8 33 28.4
8	11.96	9 17 39.5
9	1 3 58.96	+ 6 31 56.7

The observations and the comparison with the ephemeris as follows:

Date	Place	α app.	πα	δ app.	πδ	Δα cos δ	Δδ	*
		° ′ ″	″	° ′ ″	″	″	″	
Feb. 5.30210	Marseilles	340 22 44	+23	+45 12 38	+11	+ 6	+ 8	
6.31351	Marseilles	346 1 27	21	42 10 37	11	40	−34	
7.35837	Marseilles	350 43 27	19	39 8 32	12	26	−82	
8.33756	Marseilles	354 20 1	17	36 30 49	11	48	+46	
12.29512	Marseilles	3 47 56	11	27 42 46	7	1	−1	
17.31176	Marseilles	9 49 58	9	20 16 26	7	15	+28	
18.33253	Paris	10 38 6	9	19 4 39	7	+19	−69	+4, 6
18.36619	Marseilles	57	9	3 38	8	−16	+ 4	
19.28268	Marseilles	11 17 23	8	18 5 18	6	8	+ 7	
19.31145	Paris	11 18 50	7	18 3 34	7	+25	10	1
19.37301	Paris	21 28	7	17 59 48	8	38	11	1
22.28728	Marseilles	12 55 49	7	15 17 32	6	8	+17	
24.30033	Paris	13 45 6	6	13 41 54	6	59	18	2
24.31934	Paris	32	6	40 38	6	+61	−43	2
25.30478	Marseilles	14 3 4	6	12 59 9	6	−67	+48	
26.29503	Marseilles	20 9	6	18 9	5	81	44	
27.29257	Marseilles	35 23	6	11 38 56	5	−96	46	
27.34566	Paris	38 35	5	36 50	6	+46	43	3
28.29884	Marseilles	49 15	6	0 57	5	−85	+31	. .
Mar. 1.29146	Marseilles	15 1 13	5	10 24 51	5	77	− 1	. . .
2.28884	Marseilles	11 25	5	9 50 43	5	86	+ 4	. .
3.28862	Marseilles	21 21	5	17 36	5	27	− 8	. . .
4.27857	Marseilles	28 22	5	8 46 46	5	−61	+23	. .
4.29657	Paris	30 38	5	45 59	5	+64	+ 8	5, 7, 8
5.28666	Marseilles	35 38	5	15 10	4	−50	−32	.
7.30038	Paris	15 46 33	4	7 16 28	5	+29	−66	9
8.29320	Marseilles	50 34	5	6 49 27	4	52	56	. .
9.29514	Marseilles	52 41	4	23 34	4	2	14	
10.29065	Marseilles	55 33	4	5 56 52	4	42	−81	.
11.28500	Marseilles	15 57 10	+ 4	+ 5 34 43	+ 4	+43	+78	. .

The normal places are derived by using the formula $a + bt = n$ and solving by the method of least squares. They are :

	α app.	δ app.	Δα cos δ	Δδ
	° ′ ″	° ′ ″	″	″
Feb. 8.0	353 9 56.3	+37 23 51.9	+24.0	−12.3
19.0	11 6 22.4	18 22 50.0	+13.9	− 3.0
26.0	14 16 21.5	12 29 48.2	−18.9	+19.0
Mar. 3.0	15 18 38.2	9 27 11.5	−47.2	+ 0.5
9.0	15 52 28.8	6 31 1.0	+33.0	−35.4

The differential equations are constructed according to the method of Schönfeld, and are :

$+1.236\,\partial\kappa$	$-0.816\,\kappa\sqrt{2}\,\partial T$	$+2.613\,\partial q$	$+0.591\,\partial\lambda$	$-0.730\,\partial\nu$	-24.0	$= 0$
+0.109	+0.144	0.971	469	277	−13.9	
−0.103	290	669	390	107	+18.9	
188	343	578	344	−0.022	+47.2	
254	0.377	+0.539	+0.298	+0.056	−33.0	
801	1.755	−0.034	−0.476	583	+12.3	
438	0.861	+0.144	547	324	+ 3.0	
350	645	217	477	131	−19.0	
320	558	256	431	+0.027	− 0.5	
−0.301	+0.487	+0.297	−0.379	−0.071	+35.4	

The normal equations are:

$$\begin{array}{rrrrrrl}
+2.7990\,\partial\kappa & -3.5168\,\kappa\sqrt{2}\,\partial T & +2.7379\,\partial q & +1.6409\,\partial\lambda & -1.5736\,\partial\nu & -48.62 & =0\\
-3.5168 & +5.8164 & -0.9052 & -2.1104 & +1.9055 & +55.70 & \\
+2.7379 & -0.9052 & +9.0655 & +2.2311 & -2.1895 & -47.81 & \\
+1.6409 & -2.1104 & +2.2311 & +2.0112 & -1.0959 & -18.55 & \\
-1.5736 & +1.9055 & +2.1895 & -1.0959 & +1.0925 & +19.59 &
\end{array}$$

From these are derived the logarithmic elimination equations:

$$\begin{array}{rrrrrl}
\partial\kappa\ -0.0991 & \kappa\sqrt{2}\,\partial T\ +9.9904 & \partial q\ +9.7681 & \partial\lambda\ -9.7499 & \partial\nu\ -1.2398 & =0\\
 & \kappa\sqrt{2}\,\partial T\ +0.2580 & \partial q\ -8.5432 & \partial\lambda\ -8.7090 & \partial\nu\ -0.5843 & =0\\
 & & \partial q\ +9.5995 & \partial\lambda\ -9.4621 & \partial\nu\ +0.7227 & =0\\
 & & & \partial\lambda\ +8.6125 & \partial\nu\ +0.8948 & =0\\
 & & & & \partial\nu\ -0.7421 & =0
\end{array}$$

The solution of these equations gives as the most probable values for the unknown quantities:

$$\begin{aligned}
\partial\nu &= +106.9''\\
\partial\lambda &= -\ 12.2\\
\partial q &= +\ 30.5\\
\kappa\sqrt{2}\,\partial T &= -\ 46.5\\
\partial\kappa &= -\ \ 3.6
\end{aligned}$$

And substituting in the observation equations the residuals are:

$\Delta\alpha\cos\delta$	$\Delta\delta$
″	″
− 4.1	− 0.7
+26.7	−10.2
−10.0	+21.3
−43.0	+ 8.9
+30.8	−19.9

These residuals are quite large and yet there can be no doubt that they represent the accidental errors of observation. The corresponding corrections to the elements are:

$$\begin{aligned}
\partial T &= -\ 0.009260 \text{ days}\\
\partial\omega &= +10.2''\\
\partial\Omega &= +14.2\\
\partial i &= -\ 1'\ 47''.5\\
\partial q &= +\ 0.000148
\end{aligned}$$

And from these are derived the definitive elements:

ELEMENTS.

$$\begin{aligned}
T &= \text{March } 4.52197 \text{ G.M.T.}\\
\omega &= 170^\circ\ 37'\ 32''.2\\
\Omega &= 240\ \ 35\ \ 35.8\quad 1813.0\\
i &= 158\ \ 51\ \ 28.5\\
\log q &= 9.844672
\end{aligned}$$

EQUATORIAL COORDINATES.

$$\begin{aligned}
x &= [9.977428]\,r\sin(\ 21^\circ\ 46'\ 13''.0+v)\\
y &= [9.927165]\,r\sin(\ 99\ \ 42\ \ 36.0+v)\\
z &= [9.791991]\,r\sin(136\ \ 34\ \ 17.1+v)
\end{aligned}$$

A computation of the position of the comet for the dates of the normal places results in the residuals:

$\Delta\alpha\cos\delta$	$\Delta\delta$
″	″
− 4.6	− 0.6
+27.3	−10.3
−10.5	+20.9
−43.5	+ 9.5
+30.8	−20.1

A comparison of these residuals with those given above proves the numerical accuracy of the work. As might be suspected from their size, the elements are very uncertain the probable error of the time of perihelion passage being ±0.03760. The departures of WERNER's elements, as corrected by HOLETSCHEK, from these definitive elements are far within the range of uncertainty, so that the result of the investigation has been to confirm them.

Syracuse University, 1908 *April* 9.

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OBSERVATIONS OF THE SATELLITES OF *SATURN* IN 1907,

MADE WITH THE 26-INCH EQUATORIAL AT THE U.S. NAVAL OBSERVATORY,

By J. C. HAMMOND.

[Communicated by Captain W. J. BARNETTE, U.S.N., Superintendent.]

In the following observations, the position-angles are taken about the inner satellite of each pair. Usually eight settings in position-angle and eight measurements of distance were made. A magnifying power of 400 diameters was used unless otherwise stated. When the distance of *Iapetus* from *Titan* exceeded 300″, differences of right-ascension and declination were observed for this pair by the method of transits. The printed differences in α and δ in these cases are in the sense *Iapetus* minus *Titan*. They have been corrected for the motion of *Saturn* during the interval between the transits of the satellites. In all cases, corrections have been applied for differential refraction and for the constants of the instrument.

The micrometer was not disturbed during the series and the parallel remained constant. The adopted value of the correction for parallel (+0°.710) is the mean of fifteen determinations.

Bright field illumination was used throughout except in the case of *Hyperion*. The value of one revolution of the micrometer screw is the same as that hitherto used:

$$1 \text{ rev.} = 9''.9316 - 0''.00005\ (t - 50° \text{ Fah.})$$

In the last column is noted the condition of the seeing, the following abbreviations being used: p = poor, f = fair, g = good, and e = excellent seeing.

No.	Date	Wash. M.T.	p	Wash. M.T	s	Rem	No.	Date	Wash M.T.	p	Wash. M.T	s	Rem
					Tethys–Rhea.								
	1907	h m s	°	h m s	″			1907	h m s	°	h m s	″	
1	Aug. 4	13 37 2	96.28	13 40 28	79.22	g^1	14	Sept. 20	11 10 4	94.19	11 10 10	52.94	g
2	7	13 28 6	274.24	13 28 3	120.71	g	15	26	10 52 4	272.78	10 52 12	36.33	g
3	18	13 25 11	94.00	13 25 3	31.27	f	16	29	9 57 29	281.63	9 57 26	6.38	f
4	20	11 43 11	275.77	11 42 52	89.05	e	17	30	10 4 55	272.79	10 4 43	38.78	p
5	25	12 8 14	274.30	12 8 14	42.02	f	18	Oct. 1	10 30 31	275.08	10 30 21	78.75	e
6	26	11 56 28	273.07	11 56 16	72.51	e	19	2	9 33 16	94.80	9 33 20	69.72	g
7	Sept. 5	11 31 20	95.03	11 31 11	104 09	f	20	9	10 35 26	272.97	10 35 34	30.92	g
8	6	10 49 41	90.73	10 49 46	26.18	f	21	10	9 57 50	274.77	9 57 49	101.61	f
9	7	11 19 15	93.48	11 19 22	7.66	g	22	15	9 2 47	95 22	9 2 50	30.22	g
10	8	11 39 23	274.42	11 39 39	127.67	e	23	16	9 46 9	92.29	9 46 17	42.23	g
11	12	11 34 33	274.68	11 34 26	111.66	f	24	19	7 52 7	273.29	7 52 19	40.04	f
12	13	10 42 44	270 23	10 42 59	18.66	e	25	30	8 1 43	94.99	8 1 47	125.80	g
13	14	11 4 27	94.51	11 4 34	37.61	e	26	Nov. 16	7 4 56	93 68	7 5 0	64.39	g

(1) Comparisons 4, 8.; clouds interrupt.

Tethys–Dione.

No	Date	Wash. M.T.	p	Wash M.T.	s	Rem	No.	Date	Wash. M.T.	p	Wash. M.T.	s	Rem
	1907	h m s	°	h m s	″			1907	h m s	°	h m s	″	
1	Aug. 4	14 25 56	15.98	14 27 5	0.80	e^1	15	Sept. 20	10 46 13	274.20	10 46 22	33.65	g
2	4	14 28 35	8.10	. . . .	. . . .	e^2	16	29	11 53 42	282.76	11 53 46	3.90	f
3	6	13 34 18	93.47	13 34 9	88.39	e	17	30	9 53 54	95.19	9 53 59	66.59	p
4	7	13 15 35	274.60	13 15 50	97.73	e	18	Oct. 1	10 22 14	275.14	10 22 15	83 46	e
5	18	13 37 29	274.84	13 37 11	101.18	f	19	2	9 24 15	95.34	9 24 35	65 94	g
6	20	11 2 24	281.84	11 2 5	18.50	g	20	6	10 44 40	274.28	10 44 41	60 36	f
7	25	11 54 57	94.33	11 54 49	98.37	f	21	9	10 26 18	274.02	10 26 0	18.81	g
8	26	11 45 57	275.15	11 45 48	80 89	e	22	10	10 14 45	276.24	10 14 50	18.15	g
9	Sept. 5	11 19 53	94.66	11 19 56	98.40	f	23	15	9 21 56	107.28	9 21 43	2.75	f
10	6	11 6 16	275.26	11 6 17	92.86	p^3	24	16	9 36 33	91.70	9 36 36	21.38	g
11	8	11 30 58	283.67	11 31 7	8.78	e	25	19	7 42 33	95.69	7 42 20	83.10	f
12	12	10 59 42	274.55	10 59 29	87 04	p	26	26	8 6 3	279.12	8 9 40	9.62	g^4
13	13	10 53 29	94.87	10 53 32	88.93	e	27	30	7 51 39	95.30	7 51 35	94.79	g
14	14	10 54 52	275.70	10 54 52	50 20	e	28	Nov. 16	7 13 1	97.35	7 13 6	28.39	g

(1) Comparisons 2, 4. (2) Comparisons 2, –. (3) Comparisons 8, 10. (4) Comparisons 4, 8; clouds interrupt.

Dione–Rhea.

No	Date	Wash. M.T.	p	Wash M.T.	s	Rem	No.	Date	Wash. M.T.	p	Wash. M.T.	s	Rem
1	July 26	14 48 57	238.63	14 48 41	6.15	f	14	Sept. 15	10 6 36	93.66	10 6 47	99.61	f
2	Aug. 4	13 52 29	96.93	13 52 38	77.20	g	15	16	10 13 25	274.63	10 13 35	89.36	g
3	7	13 46 52	273.09	13 47 5	23.54	g	16	20	11 21 33	94.12	11 21 33	83.35	g
4	11	12 26 16	275.72	12 26 20	102.23	g	17	29	11 58 57	277.57	12 1 36	3.62	f^1
5	12	14 13 27	270.09	14 13 4	47.22	g	18	Oct. 1	10 50 52	95.81	10 50 53	4.76	e
6	18	13 50 53	94.50	13 50 52	132.80	f	19	2	9 43 52	88.22	9 43 55	4.38	g
7	20	11 13 45	274.22	11 13 44	65.70	g	20	9	10 44 1	271.43	10 43 56	12.67	g
8	26	12 21 4	106.96	12 21 4	11.80	e	21	10	10 6 19	274.51	10 6 33	83.04	f
9	29	11 13 17	91.66	11 13 31	18.82	g	22	15	9 10 46	93.93	9 10 45	28.31	g
10	30	12 9 18	274.40	12 9 34	116.11	f	23	16	9 55 40	92.74	9 55 50	20.37	g
11	Sept. 8	11 52 52	273.70	11 52 38	117.23	e	24	30	8 10 40	93.65	8 10 41	31.67	g
12	13	11 3 1	274.06	11 3 7	107.28	e	25	Nov. 16	7 24 6	91.22	7 24 7	38 73	g
13	14	11 13 22	95.03	11 13 16	88.94	e			. . . .	. . . .	. . . . .	. . .	

(1) Comparisons 4, 8. *Dione* very near *Tethys*.

Enceladus–Tethys.

No	Date	Wash. M.T.	p	Wash M.T.	s	Rem	No.	Date	Wash. M.T.	p	Wash. M.T.	s	Rem
1	Aug. 4	14 11 38	275.49	14 11 35	70.23	e	10	Sept. 26	11 17 34	278.85	11 17 30	8.53	g
2	7	13 36 34	94.99	13 36 22	2.26	g^1	11	29	10 21 28	95.24	10 21 15	63.96	f
3	11	12 17 5	278.39	12 16 53	13.52	$g^{1,2}$	12	Oct 1	10 13 54	268.76	10 13 56	7.96	e
4	18	14 17 34	100.24	14 17 13	11.28	f^3	13	5	11 41 26	274.02	11 41 16	54.61	p
5	20	11 31 42	95.16	11 31 51	80.05	e	14	9	10 12 32	274.76	10 12 33	71.67	f
6	25	12 18 57	273.90	12 18 35	61.97	f^1	15	10	9 48 16	94.98	9 48 5	65.53	f
7	Sept. 7	11 10 4	278.08	11 10 8	14.30	g	16	16	9 30 3	131.36	9 30 2	1.81	g^1
8	13	10 33 7	275.14	10 33 4	68.87	e	17	19	7 32 20	276.10	7 32 35	52.84	f
9	20	10 35 50	274.57	10 36 1	60.76	g^3	18	Nov. 16	6 56 22	275.68	6 56 29	9.76	g

(1) Comparisons 4, 4. (2) *Tethys* touching ring; measures difficult. (3) Comparisons 8, 9.

Mimas–Tethys.

No	Date	Wash. M.T.	p	Wash M.T.	s	Rem	No.	Date	Wash. M.T.	p	Wash. M.T.	s	Rem
1	Aug. 7	14 36 13	94.54	14 35 54	62.13	g^1	6	Sept. 20	10 55 18	275.51	10 55 26	57.34	g^4
2	18	13 9 21	95.45	13 9 41	13.36	f^2	7	29	11 46 15	95.90	11 46 31	57.56	f^1
3	Sept. 12	11 22 54	95.46	11 22 59	64.22	f^2	8	Oct. 6	10 53 44	281.92	10 53 40	7.15	f^5
4	13	10 19 21	271.19	10 19 15	3.81	e	9	9	10 1 19	274.74	10 1 57	58.20	f^6
5	13	11 52 44	275.42	11 53 40	1.28	e^3	10	16	9 19 12	95.96	9 19 18	69.15	g^5

(1) Comparisons 4, 4; *Mimas* faint. (2) Comparisons 4, 4; bright wires. (3) Comparisons 1, 2. (4) Comparisons 4, 5.
(5) Comparisons 4, 4. (6) Comparisons 1, 6.

Mimas–Rhea.

No.	Date	Wash. M.T.	p	Wash. M.T.	s	Rem	No.	Date	Wash. M.T.	p	Wash. M.T	s	Rem
	1907	h m s	°	h m s	″			1907	h m s	°	h m s	″	
1	Aug. 7	14 27 51	272.94	14 27 49	54.94	g^1	6	Sept. 20	11 1 44	286.78	11 1 42	5.21	g^2
2	11	12 10 31	277.14	12 10 42	25.61	g^2	7	20	11 31 49	283.14	11 32 1	7.34	g^2
3	18	13 15 24	94.65	13 15 28	45.51	$f^{2,3}$	8	Oct. 9	10 19 20	274.15	10 19 32	88.87	f^2
4	Sept. 12	11 16 10	274.00	11 16 27	47.49	$f^{2,3}$	9	16	9 24 55	94.59	9 24 57	109.00	g^2
5	13	10 25 35	270.12	10 25 36	22.08	e^2		......	....	....	....	....	

(1) Comparisons 4, 5. (2) Comparisons 4, 4. (3) Bright wires.

Rhea–Titan.

No.	Date	Wash. M.T.	p	Wash. M.T.	s	Rem	No.	Date	Wash. M.T.	p	Wash. M.T	s	Rem
1	July 25	14 25 33	96.61	14 25 52	103.90	f	13	Sept. 7	11 45 48	273.48	11 45 48	145.97	g
2	26	14 24 47	96.28	14 24 58	70.07	f	14	8	11 10 22	273.28	11 10 32	74.49	e
3	Aug. 4	14 2 2	275.86	14 2 14	183.36	e	15	13	11 13 43	94.25	11 13 43	221.68	e
4	7	13 57 48	271.26	13 57 57	72.72	g	16	14	11 24 4	94.05	11 24 9	138.61	e
5	11	12 41 52	96.27	12 41 12	163.76	e	17	16	10 26 59	94.12	10 26 51	199.34	g
6	12	14 24 33	94.39	14 24 34	236.40	g	18	20	11 40 19	274.35	11 40 29	129.51	g
7	18	14 4 57	277.27	14 4 57	102.42	f	19	26	11 5 57	94.49	11 5 43	65.83	g^1
8	20	10 51 34	274.55	10 51 37	107.20	g	20	Oct. 1	11 0 44	94.30	11 0 47	247.94	e
9	25	12 27 39	99.09	12 27 46	52.94	f	21	2	9 55 11	94.51	9 55 13	112.75	g
10	26	12 9 0	95.68	12 9 0	86.24	e	22	10	10 23 49	274.51	10 24 2	88.65	g
11	29	11 25 46	94.56	11 25 37	239.04	g	23	16	10 5 29	94.41	10 5 34	118.04	g
12	Sept. 1	12 20 11	88.88	12 19 28	30.25	f	24	30	8 19 56	91.58	8 20 8	48.84	g

(1) Comparisons 8, 9. *Titan* touching ring,

Titan–Hyperion.

No.	Date	Wash. M.T.	p	Wash. M.T.	s	Rem	No.	Date	Wash. M.T.	p	Wash. M.T	s	Rem
1	Aug. 6	13 15 0	95.88	13 14 52	83.01	g^1	10	Sept. 15	10 22 46	274.26	10 23 4	407.07	$f^{1,4}$
2	11	13 12 19	92.97	13 12 33	100.91	e^2	11	26	11 31 2	94.46	11 30 56	275.11	g^2
3	12	14 39 45	93.15	14 39 20	78.65	g	12	29	10 9 52	268.72	10 10 6	26.03	f^2
4	13	13 41 34	93.85	13 41 13	66.48	f	13	30	9 42 27	272.85	9 42 46	107.37	p^2
5	31	11 48 33	260.92	11 47 44	17.18	g^3	14	Oct. 5	11 18 23	274.20	11 18 15	153.37	p^2
6	Sept. 7	12 25 33	93.98	12 25 15	370.28	$e^{2,4}$	15	6	10 21 44	274.88	10 21 42	98.83	f^2
7	8	12 3 34	93.75	12 5 20	285.52	$e^{4,5}$	16	8	9 29 4	89.31	9 29 2	28.25	$p^{8,6}$
8	13	11 29 34	274.41	11 29 42	346.85	$e^{2,4}$	17	9	10 55 18	92.24	10 55 0	84.39	g^7
9	14	11 37 58	274.28	11 37 46	403.73	$e^{1,4}$	18	14	9 48 17	93.59	9 47 59	88.61	p^2

(1) Comparisons 4, 5; *Hyperion* very faint. (2) Comparisons 4, 4. (3) Comparisons 8, 10. (4) Power 250.
(5) Comparisons 2, 3; sky became thick. (6) *Hyperion* faint and diffuse. (7) Comparisons 5, 4. (8) Comparisons 4, 6.

Titan–Iapetus.

No.	Date	Wash. M.T.	p	Wash. M.T.	s	Rem	No.	Date	Wash. M.T.	p	Wash. M.T	s	Rem
1	July 25	14 41 23	136.27	14 41 33	73.19	f^1	10	Sept. 8	11 19 59	273.25	11 19 56	168.65	e
2	26	14 36 30	148.24	14 36 39	49.30	f	11	Oct. 5	11 29 8	240.14	11 29 9	183.71	p
3	Aug. 29	11 40 16	317.40	11 40 30	144.63	g	12	6	10 32 53	208.62	10 33 5	105.45	f
4	30	12 26 46	304.86	12 26 59	173.33	f	13	8	9 16 42	127.79	9 17 15	145.36	p
5	31	11 28 28	299.90	11 28 19	181.37	g	14	9	11 7 30	117.48	11 7 36	179.34	g
6	Sept. 1	12 3 7	297.92	12 3 22	169.10	p^1	15	10	10 33 45	113.74	10 34 3	184 49	f
7	5	11 8 41	302.14	11 8 50	59.13	f	16	14	9 36 27	109.60	9 36 29	76.98	p
8	6	11 25 23	290.12	11 25 53	64.44	$p^{1,2}$	17	15	9 33 48	101.80	9 33 44	68.61	f
9	7	11 35 22	278.41	11 35 32	101.25	g	18	16	10 15 43	92.29	10 15 52	86.89	g

(1) Bright wires. (2) Comparisons 8, 10.

Titan–Iapetus [rectangular].

No.	Date	Wash. M.T.	$\Delta\alpha$	Wash. M.T.	$\Delta\delta$	Rem	No.	Date	Wash. M.T.	$\Delta\alpha$	Wash. M.T	$\Delta\delta$	Rem
			s		″					s		″	
1	Aug. 6	14 9 23	+45.719	14 9 23	+ 30.79	$f^{1,2}$	8	Sept. 14	11 57 4	−46.879	11 57 4	−16.86	e^1
2	7	14 13 6	+44.959	14 13 6	+ 43.38	$g^{1,2}$	9	16	10 46 4	−47.027	10 46 4	−35.56	g^1
3	11	12 58 38	+29.517	12 58 38	+ 92.65	$e^{1,2}$	10	20	11 54 14	−30.837	11 54 14	−82.59	g^1
4	12	14 53 49	+25.783	14 53 49	+101.32	$g^{1,2}$	11	29	10 39 39	−40.539	10 39 39	−87.94	f^1
5	13	13 25 14	+23.829	13 25 14	+106.79	$f^{1,2}$	12	30	10 20 54	−40.002	10 20 54	−86.07	p^1
6	20	12 2 19	+38.977	12 2 19	+ 99.78	$e^{1,2}$	13	Oct. 1	11 13 27	−37.244	11 13 27	−85.20	e^1
7	Sept. 13	11 44 59	−43.659	11 44 59	− 9.82	e^1	14	2	10 8 9	−32.774	10 8 9	−85.80	g^1

(1) Comparisons 15, 5. (2) Bright wires.

The following eclipses of the satellites were observed. In the eclipse of *Titan*, only the time that it was last seen was recorded. In the other eclipses, a few estimates of relative brightness were made. The observations with the 12-inch equatorial and the observation of Dec. 12 with the 26-inch equatorial were made by Mr. G. H. PETERS.

26-INCH EQUATORIAL.

1907 Aug. 25. Disappearance of *Titan*.

Wash. M.T.	
h m s	
15 56 21	Last seen.

Seeing fair.

1907 Nov. 11. Reappearance of *Tethys*.

Wash. M.T.	
h m s	
6 9 22	First seen.
6 11 17	Entirely out.

Seeing rather poor; a little hazy. Power 400.

1907 Nov. 16. Reappearance of *Rhea*.

Wash. M.T.	
h m s	
5 50 38	Partly out. Late in beginning obs'n.
5 51 58	As bright as *Tethys*.
5 53 58	Probably entirely out.

Seeing excellent Power 400.

1907 Nov. 25. Reappearance of *Rhea*.

Wash. M.T.	
h m s	
6 46 45	First seen.
6 47 35	As bright as *Enceladus*.
6 48 35	As bright as *Dione*.
6 49 35	Entirely out.

Seeing fair but somewhat unsteady and blurred. Power 400.

1907 Dec. 12. Reappearance of *Dione*.

Wash. M.T.	
h m s	
7 5 52	First seen.

Seeing very bad. Observation not certain.

12-INCH EQUATORIAL.

1907 Nov. 11. Reappearance of *Tethys*.

Wash. M.T.	
h m s	
6 10 9	Satellite probably half out.

Seeing poor. Power 230

1907 Nov. 16. Reappearance of *Rhea*.

Wash. M.T.	
h m s	
5 50 26	First seen.
5 55 11	As bright as *Tethys*.
5 57 56	Perhaps out.
5 58 40	Certainly out.

Seeing good. Power 230.

1907 Nov. 25. Reappearance of *Rhea*.

Wash. M.T.	
h m s	
6 47 27	First seen.
6 49 47	A little brighter than *Dione*.
6 55 18	Certainly out.

When first seen, *Rhea* was fairly conspicuous and was probably out a few seconds.

Seeing poor. Power 230.

ELEMENTS AND EPHEMERIS FOR 1907 *YD*.

BY ETTA M. EATON.

[Communicated by Captain W. J. BARNETTE, U.S.N., Superintendent, U.S.Naval Observatory.]

From the observations of 1907 March 16, April 3, and April 20, made at Washington, the following provisional elements have been computed:

ELEMENTS.

$$M = 329^\circ\ 53'\ 13''.9 \qquad \phi = 11^\circ\ 48'\ 19''.2$$

$$\left.\begin{array}{l}\omega = 280\ \ 3\ 56.8\\ \Omega = 303\ 26\ 54.7\\ i = 4\ 37\ 56.5\end{array}\right\}1907.0 \qquad \begin{array}{l}\log a = 0.490550\\ \log \mu = 2.814196\\ \mu = 651''.923\end{array}$$

The observations, made at Washington, and published in the *Journal*, No. 599, give the following corrections to an ephemeris, computed from these elements:

1907	O–C α	O–C δ
	s	″
March 16	–0.09	+0.3
20	–0.18	+1.6
April 3	–0.26	0.0
11	–0.17	–0.5
April 12	–0.36	–0.1
17	–0.04	–0.7
20	–0.13	+0.4

Opposition July 25, 1908. Approximate magnitude 12.7.

EPHEMERIS FOR 1907 *YD*.

1908 G.M.T.	App. R.A.	App. Decl.	Aberr. T.
	h m s	° ″	m s
June 26.5	20 40 30.43	–19 15 10.6	15 39
30.5	20 38 6.89	–19 18 18.6	15 29
July 4.5	20 35 24.76	–19 22 15.7	15 22
8.5	20 32 26.66	–19 26 49.9	15 16
12.5	20 29 15.61	–19 31 49.5	15 12
16.5	20 25 54.68	–19 37 3.4	15 11
20.5	20 22 27.16	–19 42 21.3	15 11
24.5	20 18 56.76	–19 47 31.7	15 14
28.5	20 15 27.38	–19 52 24.5	15 19
Aug. 1.5	20 12 2.68	–19 56 50.9	15 26
5.5	20 8 16.55	–20 0 13.5	15 35
9.5	20 5 42.14	–20 3 56.9	15 47
13.5	20 2 52.41	–20 6 25.9	16 0
17.5	20 0 19.82	–20 8 8.2	16 15
21.5	19 58 6.12	–20 9 3.0	16 33
25.5	19 56 13.77	–20 9 11.7	16 52

OBSERVATIONS OF MINOR PLANETS,

MADE WITH THE 18-INCH EQUATORIAL OF THE FLOWER OBSERVATORY,

BY SAMUEL G. BARTON.

1906-7 Wash. M.T.	*	Comp.	Δα	Δδ	App. α	App. δ	log pΔ		Red. to App. Pl.	
(121) *Hermione.*										
1906 h m s			m s	′ ″	h m s	° ′ ″			s	″
Nov. 23 9 32 0	1	10 ,10	+0 14.51	−0 44.7	2 23 27.14	+ 8 1 47.5	*n*8.926	0.741	+3.13	+11.6
23 10 8 51	2	27 , 5	−0 36.59	+4 0.9	2 23 26.61	+ 8 1 45.2	*n*8.059	0.735	+3.12	+11.5
(90) *Antiope.*										
Nov. 23 12 48 43	3	29 , 6	+0 21.29	−2 29.9	4 53 59.42	+22 33 28.3	7.930	0.415	+3.61	+ 0.3
23 13 30 56	4	14 , –	−1 0.26	. . . . . .	4 53 57.81	. . . .	8.991	. . . .	+3.60	+ 0.2
1907										
(21) *Lutetia.*										
Jan. 30 10 30 0	5	30 , 6	+1 8.71	+2 54.4	8 53 38.96	+21 13 55.8	*n*9.335	0.486	+0.68	− 6.6
(511) *Davida.*										
Jan. 30 16 10 0	6	12 , –	−3 6.52	. . . . . .	10 6 17.13	. . . .	9.458	. . . .	+0.58	. . . .
Feb. 8 9 5 33	7	20 , 6	+0 34.06	+7 10.3	9 59 47.27	+26 31 40.8	*n*9.595	0.498	+0.72	− 7.1
8 10 49 52	8	23 , 4	+5 20.49	−4 30.4	9 59 43.35	+26 32 16.3	*n*9.367	0.345	+0.73	− 7.0
11 9 12 1	9	24 , 5	+4 37.42	+5 23.7	9 57 23.25	+26 58 25.1	*n*9.578	0.475	+0.63	− 6.9
11 9 13 33	10	21 , 5	+3 33.25	+6 16.0	9 57 23.15	+26 58 22.7	*n*9.576	0.473	+0.63	− 6.9
12 8 43 21	11	18 , 5	−6 0.62	−0 27.9	9 56 35.59	+27 6 45.9	*n*9.615	0.498	+0.79	− 6.9
12 8 49 43	12	22 , 5	−1 1.20	−0 11.5	9 56 35.52	27 6 47.6	*n*9.606	0.508	+0.79	− 7.0
13 8 18 29	13	27 , 5	+0 44.07	−5 5.4	. . . .	. . . .	*n*9.640	0.382	+0.80	− 6.8
13 8 18 29	14	27 , 5	−1 45.87	−1 26.5	. . . .	. . . .	*n*9.640	0.382	+0.80	− 6.8
21 12 36 7	15	26 , 4	+2 4.22	+4 32.6	9 49 12.46	+28 17 5.4	9.109	0.268	+0.83	− 6.0
21 12 36 7	16	26 , 4	−3 55.47	+5 0.6	9 49 12.60	+28 17 7.5	9.109	0.268	+0.83	− 6.1
Mar. 2 12 9 7	17	27 , 5	+3 4.01	+1 6.6	9 42 33.37	+29 9 10.7	9.241	0.259	+0.85	− 4.8
2 12 9 7	18	27 , 5	+2 42.76	+1 8.5	9 42 33.35	+29 9 8.8	9.241	0.259	+0.85	− 4.8
4 11 21 6	19	30 , 5	−1 41.21	−3 43.0	9 41 14.80	+29 18 9.5	8.884	0.203	+0.85	− 4.6
6 9 4 50	19	27 , 5	−2 53.81	+4 10.4	9 40 2.20	+29 26 3.0	*n*9.312	0.267	+0.85	− 4.5
(402) *Chloe.*										
Feb. 22 9 36 34	20	10 ,10	−0 16.31	+5 10.8	8 30 56.90	+21 35 48.3	*n*8.921	0.444	+0.73	− 5.9
23 7 57 33	21	30 , 6	+1 8.49	−5 39.6	8 30 23.74	+21 42 59.2	*n*9.429	0.497	+0.73	− 5.8
23 8 36 12	22	29 , 6	+0 55.33	−5 28.4	8 30 22.86	+21 43 11.5	*n*9.294	0.468	+0.73	− 5.8
25 10 25 26	23	26 . 5	+2 41.30	−2 0.6	8 29 16.45	+21 58 37.3	8.680	0.431	+0.70	− 5.6
27 10 53 22	24	27 , 6	+0 34.51	+1 24.7	8 28 18.86	+22 12 51.0	9.097	0.437	+0.70	− 5.4
Mar. 2 9 40 52	25	29 , 6	+3 27.29	−0 46.0	8 27 8.72	+22 32 12.4	*n*5.308	0.416	+0.64	− 5.0
4 8 49 11	26	27 , 5	+2 3.64	−0 53.3	8 26 30.96	+22 44 12.9	*n*8.964	0.419	+0.63	− 4.9
4 8 49 11	27	27 , 5	−0 35.26	+0 40.3	8 26 30.76	+22 44 13.0	*n*8.964	0.419	+0.63	− 4.9
6 12 3 14	28	28 , 7	+1 1.88	−0 15.1	8 25 57.87	+22 56 18.1	9.496	0.499	+0.62	− 4.8
6 12 3 14	29	28 , 7	+0 52.85	+0 3.8	8 25 57.82	+22 56 19.1	9.496	0.499	+0.62	− 4.8
(79) *Eurynome.*										
Feb. 27 13 56 13	30	30 , 5	−1 19.20	−2 11.2	11 42 22.57	− 2 45 35.9	8.979	0.773	+0.84	− 5.2
Mar. 2 13 30 44	31	27 , 6	−0 27.45	−2 56.8	11 39 53.08	− 2 26 52.3	8.867	0.771	+0.86	− 5.5
2 14 11 46	32	12 , 5	−1 43.52	+2 33.0	11 39 52.00	− 2 26 41.2	9.118	0.770	+0.86	− 5.5
15 9 5 10	33	28 , 6	+0 30.88	−1 0.7	11 28 31.17	− 0 57 3.0	*n*9.475	0.755	+0.97	− 6.8
16 9 6 21	33	29 , 7	−0 22.75	+6 22.9	11 27 37.54	− 0 49 39.5	*n*9.462	0.756	+0.97	− 6.9
(82) *Alkmene.*										
Feb. 27 12 52 24	34	26 , 6	−1 4.83	+2 56.7	12 9 33.69	+ 2 3 22.1	*n*8.918	0.731	+0.76	− 5.3
Mar. 6 13 3 53	35	30 , 5	−0 26.62	+4 6.6	12 4 29.56	+ 2 29 12.2	7.553	0.726	+0.85	− 5.8
11 13 39 50	36	10 ,10	−0 12.12	+7 8.0	12 0 24.23	+ 2 49 30.6	9.071	0.724	+0.93	− 6.3
11 13 59 13	37	6 ,10	−0 2.92	+7 30.9	12 0 23.26	+ 2 49 32.0	9.193	0.725	+0.93	− 6.3
15 10 9 58	38	24 , 5	−2 44.25	−2 53.1	11 57 7.01	+ 3 5 17.0	*n*9.383	0.725	+0.95	− 6.4
16 10 57 23	38	19 , 5	−3 37.85	+5 39.2	11 56 13.41	+ 3 13 49.4	*n*9.174	0.721	+0.95	− 6.3
22 9 56 11	39	8 , –	−1 33.55	. . . .	11 51 5.51	. . . .	*n*9.318	0.719	+0.99	− 6.6
22 9 57 3	40	10 , –	+3 24.36	. . . .	11 51 5.79	. . . .	*n*9.315	0.719	+0.99	− 6.5

1907 Wash. M.T.	*	Comp.	Δα	Δδ	App. α	App. δ	log pΔ		Red. to App. Pl.	
					(11) *Parthenope.*					
1907 h m s			m s	′ ″	h m s	° ′ ″			s	″
Mar. 11 10 8 50	41	24 , 6	−3 33.24	−0 13.4	10 48 27.81	+12 26 28.5	n9.188	0.615	+0.92	− 6.8
13 8 27 18	42	15 . −	+1 5.45	....	10 46 46.82	.. ....	n9.494	....	+0.91	...
13 8 42 36	42	— , 6	....	+6 32.1	....	+12 38 29.6	....	0.638	....	− 6.7
15 7 59 4	43	29 , 6	−0 47.19	+4 43.2	10 45 4.87	+12 50 15.6	n9.530	0.650	+0.90	− 6.5
16 7 59 9	44	18 , 5	−5 10.29	+4 9 3	10 44 14.43	+12 56 2.6	n9.521	0.647	+0.90	− 6.4
22 8 30 52	45	12 ,12	+0 5.18	−1 27.2	10 39 29.31	+13 27 36.8	n9.377	0.615	+0.89	− 6.2
					(40) *Harmonia.*					
Mar. 11 11 42 49	46	11 ,10	−0 13.67	−3 56.6	11 26 26.23	+11 19 27.8	n8.639	0.622	+0.93	− 6.7
11 12 16 35	47	10 , 9	+0 7.68	−4 3.9	11 26 24.60	+11 19 36.4	8.385	0.622	+0.93	− 6.7
16 9 51 54	48	30 , 7	+1 26.73	−5 30.3	11 21 37.57	+11 50 51.7	n9.321	0.630	+0.93	− 6.5
					(68) *Leto.*					
Mar. 15 11 36 5	49	30 , 6	+0 42.48	+1 56.1	12 47 45.13	+ 2 44 10.1	n9.255	0.726	+0.90	− 5.8
16 12 11 39	49	10 ,10	−0 4.13	+6 14.0	12 46 58.52	+ 2 48 28.0	n9.019	0.724	+0.90	− 5.7
16 12 54 14	50	17 , 4	−3 21.91	−1 36.5	12 46 57.20	+ 2 48 32.4	n8.331	0.713	+0.90	− 5.7
Apr. 19 8 59 16	51	10 ,11	−0 4.91	−6 2.2	12 19 43.78	+ 4 44 44.2	n9.215	0.706	+1.18	− 4.5
19 9 37 23	52	30 . 5	−1 28.43	+2 2.1	12 19 42.86	+ 4 44 50.8	n8.964	0.704	+1.18	− 4.5
					(57) *Mnemosyne.*					
Apr. 19 12 4 38	53	30 , 6	+1 18.41	−1 15.5	12 59 15.70	− 6 24 57.7	9.077	0.800	+1.19	− 4.4
					(199) *Byblis.*					
May 17 9 42 32	54	27 . 5	+1 9.25	+2 17.5	15 24 38.64	− 2 47 54.0	n9.341	0.771	+1.47	− 1.9
18 8 37 15	54	32 , −	+0 19.38	....	15 23 48.77	... .	n9.498	....	+1.47	− 1.9
20 9 10 10	54	24 , 5	−1 25.87	−4 50.2	15 22 3.54	− 2 55 1.6	n9.397	0.771	+1.49	− 1.8
21 10 3 58	55	26 , 5	+2 49.86	−1 34.3	15 21 11.05	− 2 57 45.7	n9.165	0.774	+1.47	− 1.7
21 10 3 58	56	26 , 5	+2 45.05	+0 5.9	15 21 11.04	− 2 57 44.1	n9.165	0.774	+1.47	− 1.7
					(41) *Daphne*					
June 8 9 35 51	57	10 , 12	−0 18.57	+3 46.9	15 32 38.68	+ 7 53 59.6	n8.942	0.479	+1.54	− 1.6

Mean Places of Comparison-Stars for the beginning of the Year.

*	α	δ	Authority	*	α	δ	Authority
	h m s	° ′ ″			h m s	° ′ ″	
1	2 23 9.50	+ 8 2 20.6	Fund. Catal.	30	11 43 40.93	− 2 43 19.5	Strassburg. A.G. 4419
2	2 24 0.08	+ 7 57 32.8	Leipzig II. A.G. 923	31	11 40 19.67	− 2 23 50 0	" " 4404
3	4 53 34.52	+22 35 57.9	Berlin, (B.). A.G. 1586	32	11 41 34.66	− 2 29 8.7	" " 4407
4	4 54 54.47	+22 28 31.6	" " 1596	33	11 27 59.32	− 0 55 55.5	Nicolajew. A.G. 3269
5	8 52 29.57	+21 11 8.0	" " 3611	34	12 10 37.76	+ 2 0 30.7	Albany. A.G. 4453
6	10 9 23.07	+25 2 21.9	Camb. Eng., A.G. 5264	35	12 4 55.33	+ 2 25 11.4	½(Albany A.G. 44[illegible]+ Greenwich 1880 No. 1892)
7	9 59 12.49	+26 24 37.6	" " 5197	36	12 0 35.42	+ 2 42 28.9	Albany, A.G. 4420
8	9 54 22.13	+26 36 53.7	" " 5177	37	12 0 25.25	+ 2 42 7.4	" " 4419
9	9 52 45.20	+26 53 8.3	" " 5164	38	11 59 50.31	+ 3 8 16.5	" " 4413
10	9 53 49.27	+26 52 13.6	" " 5172	39	11 52 38.07	+ 3 34 4.9	" " 4383
11	10 2 35.42	+27 7 20.7	" " 5220	40	11 47 40.44	+ 3 36 54.1	" " 4365
12	9 57 35.93	+27 7 6.1	" " 5190	41	10 52 0.13	+12 26 48.7	Leipzig I. A.G. 4153
13	....	....	B.D. 27° 1835	42	10 45 40.46	+12 32 4.2	" " 4132
14	....	....	B.D. 27° 1838	43	10 45 51.16	+12 45 38.9	" " 4134
15	9 47 7.41	+28 12 38.8	Camb. Eng., A.G. 5126	44	10 49 23.82	+12 51 59.7	" " 4149
16	9 53 7.24	+28 12 13.0	½(A.G. Cambridge, Eng., 5169+ Paris 12,246)	45	10 39 23.24	+13 29 10.2	" " 4098
17	9 39 28.51	+29 8 8.9	Camb. Eng., A.G. 5079	46	11 26 38.97	+11 23 31.1	" " 4316
18	9 39 49.74	+29 8 5.1	" " 5082	47	11 26 15.99	+11 23 17.0	" " 4314
19	9 42 55.16	+29 21 57.1	" " 5091	48	11 20 9.91	+11 56 28.5	" " 4287
20	8 31 12.48	+21 30 43.4	Berlin (B.), A.G. 3445	49	12 47 1.75	+ 2 42 19.7	Albany, A.G. 4588
21	8 29 11.52	+21 48 44.6	" " 3428	50	12 50 18.21	+ 2 50 14.6	" " 4603
22	8 29 26.80	+21 48 45.7	" " 3430	51	12 19 47.51	+ 4 50 50.9	½(Alb. A.G. 4477+Leip. 6111)
23	8 26 34.45	+22 0 43.5	" " 3410	52	12 21 10.11	+ 4 42 53.2	½(Alb. A.G. 4484+Leip. 6119)
24	8 27 13.65	+22 11 31.7	" " 3420	53	12 57 56.10	− 6 23 37.8	Wien Ott., A.G. 4703
25	8 23 10.79	+22 33 3.4	" " 3395	54	15 23 27.92	− 2 50 9.6	Strassburg. A.G. 5397
26	8 24 26.69	+22 45 11.1	" " 3398	55	15 18 19.72	− 2 56 9.7	" " 5370
27	8 27 5.39	+22 43 37.7	" " 3416	56	15 18 21.52	− 2 57 48.3	" " 5371
28	8 24 55.37	+22 56 38.0	" " 3400	57	15 32 55.71	+ 7 50 11.1	Leipzig. II A.G. 7026
29	8 25 4.35	+22 56 20.1	" " 3403				

OBSERVATIONS OF THE SATELLITES OF *URANUS* IN 1907,

MADE WITH THE 26-INCH EQUATORIAL AT THE U.S. NAVAL OBSERVATORY,

By MATT FREDERICKSON.

[Communicated by Rear-Admiral ASA WALKER, U.S.N., Superintendent.]

In the following observations *Oberon* was referred to *Titania* and *Titania* to *Uranus*. Eight settings in position angle and eight measurements of distance were made except in one case noted below. A magnifying power of 375 diameters was used throughout. The magnifying power of the same eye-piece when hitherto referred to has been given as 400.

The micrometer was not disturbed during these observations and the parallel was determined on various dates, sometimes before the night's work. The adopted value of the correction for parallel was +0°.700, the mean of six determinations. Corrections have been applied for differential refraction and for the instrumental constants.

Bright wire illumination was used exclusively. The value of one revolution of the screw is the same as that hitherto used.

$$1 \text{ rev.} = 9''.9316 - 0.00005\,(t - 50° \text{ Fahr.})$$

In the last column is given the condition of the seeing, the following abbreviations being used: *b* = bad, *p* = poor, *f* = fair, *g* = good and *e* = excellent.

Titania — Oberon.

No.	Date	Wash. M.T.	*p*	Wash. M.T.	*s*	Rem	No.	Date	Wash. M.T.	*p*	Wash. M.T.	*s*	Rem
	1907	h m s	°	h m s	″			1907	h m s	°	h m s	″	
1	May 11	15 1 54	128.88	15 1 47	63.06	*f*	13	June 30	12 12 16	204.12	12 12 18	72.84	*f*[6]
2	12	14 57 45	162.36	14 58 20	70.91	*f*	14	July 3	11 1 48	123.49	11 1 50	69.11	*f*
3	13	14 45 24	192.10	14 45 6	75.37	*g*	15	4	12 26 47	160.02	12 26 40	71.08	*p*
4	14	14 41 55	221.81	14 42 16	72.73	*g*	16	14	11 42 36	63.03	11 42 12	11.02	*f*
5	20	14 43 5	58.60	14 43 56	49.32	*f*	17	16	11 10 12	57.74	11 10 49	18.14	*f*
6	21	14 33 53	90.96	14 34 48	40.47	*p*[1]	18	27	9 0 54	35.76	9 0 39	75.06	*f*
7	June 6	13 5 40	107.46	13 5 50	67.36	*e*	19	30	9 15 7	139.24	9 15 2	64.60	*g*[7]
8	8	12 39 43	175.55	12 39 0	75.34	*b*[2]	20	31	8 56 21	171.34	8 56 56	64.35	*g*
9	15	12 23 48	219.13	12 24 20	43.20	*f*[3]	21	Aug. 7	11 14 57	9.03	11 15 8	14.32	*f*
10	16	12 21 12	68.12	12 21 2	33.79	*g*	22	11	9 7 12	28.76	9 6 31	28.81	*e*
11	17	13 35 23	100.09	13 35 45	24.44	*f*[4]	23	12	8 50 59	53.17	8 50 40	35.25	*e*
12	19	13 51 44	132.72	13 51 25	10.62	*f*[5]							

[1] Satellites difficult. [2] Blurred ; satellites invisible much of the time. [3] Diffuse. [4] Satellites exceedingly faint. [5] Observation difficult. [6] Unsteady. [7] Satellites faint.

Uranus — Titania.

No.	Date	Wash. M.T.	*p*	Wash. M.T.	*s*	Rem	No.	Date	Wash. M.T.	*p*	Wash. M.T.	*s*	Rem
1	May 11	15 35 28	283.76	15 35 0	28.71	*f*	13	June 30	12 35 12	8.91	12 35 5	32.69	*f*
2	12	15 27 18	330.10	15 27 18	31.02	*f*	14	July 3	11 42 42	313.30	11 42 41	30.27	*f*
3	13	15 31 17	8.93	15 30 50	32:38	*g*	15	4	12 38 45	356.37	12 38 54	32.68	*p*
4	14	15 12 12	45.65	15 11 50	31.31	*g*	16	14	12 57 10	45.78	12 56 50	31.61	*p*
5	20	15 20 33	298.30	15 21 46	29.31	*f*	17	16	11 26 28	130.34	11 27 13	30.17	*f*
6	21	15 3 23	340.85	15 4 35	31.92	*f*	18	27	9 17 54	218.58	9 18 12	32.11	*p*
7	June 6	13 47 31	274.67	13 46 49	29.30	*p*[1]	19	30	9 31 11	346.24	9 30 58	31.38	*p*
8	8	13 13 56	0.43	13 13 59	31.91	*b*[2]	20	31	9 12 46	24.49	9 12 17	32.15	*g*
9	15	12 55 25	288.66	12 55 10	28.83	*f*[3]	21	Aug. 7	11 37 42	321.82	11 49 39	30.62	*p*[5]
10	16	12 51 25	332.77	12 51 31	31.37	*g*	22	11	9 35 26	121.33	9 36 21	29.46	*f*
11	17	14 6 29	13.54	14 6 45	33.18	*f*[4]	23	12	9 9 28	163.79	9 9 10	31.46	*e*
12	19	14 12 45	94.18	14 12 58	29.51	*f*							

[1] Hazy; satellites visible only at intervals. [2] Blurred, unsteady, diffused. [3] Unsteady. [4] Sky thick. [5] Four settings in position-angle; eight measurements of distance

MAXIMA OF LONG-PERIOD VARIABLES,

By IDA WHITESIDE

The following maxima of long-period variables were determined from the single light-curves. The observations before October 1, were made with a four-inch Dolland telescope. Those since that time were made with a six-inch Clark lens, at the Whitin Observatory. Column 1 gives the Harvard number, as well as the name of the variable. The magnitudes used for the comparison-stars were all Harvard photometric magnitudes. The predicted times of maxima are those given in CHANDLER'S "Ephemerides of Long-Period Variables."

Star	Date of Maximum	Predicted Date	Mag.	No. Obs.	Time Covered by Observations
001755, *T Cassiopeiae*	Sept. 15, 1907	Sept. 26, 1907	7.62	19	July 3, 1907 – Jan. 6, 1908
004047, *U Cassiopeiae*	After Mar. 31	Feb. 9, 1908	8.32+	12	Dec. 5, 1907 – Apr. 9, 1908
021024, *R Arietis*	Jan. 25, 1908	Jan. 11, 1908	8.00	14	Nov. 9, 1907 – Mar. 21, 1908
030514, *U Arietis*	Jan. 31, 1908	Jan. 15, 1908	7.43	13	Nov. 9, 1907 – Mar. 21, 1908
044617, *V Tauri*	Feb. 4, 1908	Feb. 15, 1908	9.66	9	Dec. 7, 1907 – Mar. 21, 1908
045307, *R Orionis*	Jan. 2, 1908	Feb. 7, 1908	9.45	11	Dec. 7, 1907 – Apr. 17, 1908
050003, *V Orionis*	Dec. 5, 1907	Dec. 9, 1907	9.42	10	Oct. 30, 1907 – Feb. 18, 1908
050953, *R Aurigae*	Before Dec. 7	Feb. 1, 1908	>8.60	12	Dec. 7, 1907 – Apr. 9, 1908
065355, *R Lyncis*	Dec. 4, 1907	Dec. 27, 1907	8.44	11	Oct. 30, 1907 – Feb. 18, 1908
071713, *V Geminorum*	Jan. 25, 1908	Jan. 25, 1908	8.80	11	Nov. 11, 1907 – Mar. 21, 1908
074323, *T Geminorum*	Jan. 15, 1908	Feb. 5, 1908	8.62	11	Dec. 12, 1907 – Mar. 21, 1908
103769, *R Ursae Majoris*	Before Oct. 15	Nov. 15, 1907	7.0 +	9	Oct. 15, 1907 – Jan. 22, 1908
123160, *T Ursae Majoris*	Dec. 19, 1907	Dec. 19, 1907	7.02	12	Oct. 15, 1907 – Mar. 21, 1908
141954, *S Bootis*	Aug. 3, 1907	July 15, 1907	8.80	16	May 3, 1907 – Sept. 24, 1907
142584, *R Camelopardalis*	Before June 18	Aug. 1, 1907	8.63	11	June 8, 1907 – Sept. 24, 1907
153378, *S Ursae minoris*	Aug. 3, 1907	Aug. 10, 1907	8.45	16	June 8, 1907 – Nov. 9, 1907
154615, *R Serpentis*	Before June 18	Aug. 3, 1907	7.20	12	June 8, 1907 – Sept. 24, 1907
162119, *U Herculis*	June 27, 1907	June 27, 1907	8.17	15	Apr. 10, 1907 – Sept. 24, 1907
163266, *R Draconis*	July 23, 1907	July 10, 1907	7.81	16	May 13, 1907 – Oct. 10, 1907
171401, *Z Ophiuchi*	After Sept. 21	Aug. 22, 1907	7.70+	10	June 8, 1907 – Oct. 30, 1907
183308, *X Ophiuchi*	July 4, 1907	July 9, 1907	6.78	19	May 13, 1907 – Nov. 8, 1907
191019, *R Sagittarii*	Oct. 3, 1907	Oct. 17, 1907	7.05	12	Aug. 8, 1907 – Nov. 20, 1907
194048, *RT Cygni*	Dec. 14, 1907	Jan. 2, 1908	7.82	8	Nov. 9, 1907 – Dec. 31, 1907
201008, *R Delphini*	Aug. 17, 1907	Sept. 14, 1907	8.53	13	July 3, 1907 – Nov. 8, 1908
210868, *T Cephei*	June 16, 1907	June 16, 1907	5.60	22	Apr. 12, 1907 – Nov. 20, 1907
230110, *R Pegasi*	Sept. 16, 1907	Oct. 12, 1907	8.00	12	Aug. 8, 1907 – Dec. 3, 1907
235350, *R Cassiopeiae*	Aug. 25, 1907	Sept. 8, 1907	6.55	19	July 3, 1907 – Jan. 6, 1908

Whitin Observatory, Wellesley College, Mass.

OBSERVATIONS OF VARIABLE STARS.—No. 11.

BY WM. E. SPERRA.

The following observations of *U Geminorum* and *SS Cygni* were made in the years 1904–1906, at Barberton, Ohio, and continue the series published in *A. J.* 557. Because of poor health during those years the series is much broken into.

In *A. J.* 476 is given position coordinates for the identification of my comparison stars used in observing *SS Cygni*, and their magnitude estimates adjusted to my light scale. That my magnitude estimates of *U Geminorum* may also be comparable with any other scale, I herewith give approximate coordinates for my comparison stars and magnitudes based on those of the DM., but adjusted to my scale. The observations of this last named star published in *A. J.* 476 and 557, conform to this scale.

2815 *U Geminorum.*

1904	Nov.	29.61	9.62	1904	Nov.	30.63	9.63
1906	Jan.	31.59	11.21	1906	Feb.	8.79	11.0 <
	Feb.	5.70	10.70>				

Below are given the co-ordinates of the comparison stars from the variable, the position of which for 1900 is

$$\alpha = 7^{h}\,49^{m}\,10^{s}\ ,\quad \delta = +22^{\circ}\,15'.8.$$

	s	′	M		s	′	M
a	+4	−20	8.70	*e*	−29	−10	10.70
b	+78	−10	9.20	*f*	0	+6	11.00
c	+86	−12	9.40	*g*	+16	0	11.30
d	−77	+14	10.10	*h*	+4	+4	11.50

7792 *SS Cygni.*

			M				M
1904	June	5.62	9.24	1904	June	9.65	10.82
1904	Sept.	16.51	8.56	1904	Sept.	20.57	9.68
1904	Oct.	30.56	8.37	1904	Nov.	2.62	8.64
		31.58	8.60			3.62	8.73
	Nov.	1.56	8.62			4.57	8.68
1905	Aug.	29.62	10.92	1905	Aug.	31.59	11.22
1905	Sept.	18.60	8.59	1905	Sept.	23.71	10.46
		20.57	8.69			24.54	10.41
		22.58	9.12				
1905	Nov.	22.67	9.56	1905	Nov.	24.55	8.65
		23.66	8.54			26.61	8.68
1906	July	25.60	10.21	1906	July	26.61	10.33

Cleveland, Ohio.

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OBSERVATIONS OF MINOR PLANETS AND COMETS,

MADE WITH THE 26-INCH AND 12-INCH EQUATORIALS AT THE U.S. NAVAL OBSERVATORY,

By J. C. HAMMOND and M. FREDERICKSON.

[Communicated by Captain W. J. Barnette, U.S.N., Superintendent.]

1907 Wash. M.T.	*	Comp.	$\Delta\alpha$	$\Delta\delta$	App. α	App. δ	log $p\Delta$		Red. to App. Pl.	
					(554) *Peraga.*					
h m s			m s	′ ″	h m s	° ′ ″			s	″
Aug. 30 11 48 17	1	24 , 5	−0 18.92	+ 0 21.9	23 38 49.57	+ 2 10 44.6	*n*9.182	0.720	+2.29	+14.5†
Sept. 6 9 46 55	2	25 , 5	−0 38.86	+ 2 22.8	23 33 5.24	+ 1 46 49.4	*n*9.482	0.727	+2.37	+15.4†
11 10 30 47	3	25 , 5	−1 9.92	− 4 17.5	23 28 30.47	+ 1 25 15.8	*n*9.277	0.728	+2.41	+15.7†
13 9 50 41	4	25 , 5	+3 39.58	− 6 41.8	23 26 39.60	+ 1 16 2.7	*n*9.385	0.730	+2.43	+15.9†
20 9 53 15	5	25 , 5	−2 7.62	− 3 46.7	23 20 4.75	+ 0 41 16.9	*n*9.250	0.734	+2.46	+16.4†
20 10 11 15	6	25 , 5	−2 27.36	+ 4 14.8	23 20 4.03	+ 0 41 12.6	*n*9.158	0.734	+2.46	+16.4†
29 12 40 6	7	25 , 5	−1 35.15	− 6 45.5	23 12 1.68	− 0 5 29.7	9.357	0.741	+2.45	+16.7†
Estimated magnitudes: Aug. 30, 11.0; Sept. 13, 10.3.										
					(179) *Klytaemnestra.*					
Sept.23 8 31 43	8	25 , 5	+1 15.41	+ 4 57.3	22 26 6.86	+ 3 17 22.2	*n*9.316	0.711	+2.37	+16.8*
23 8 31 43	9	25 , 5	−3 32.12	+ 1 18.8	22 26 6.81	+ 3 17 23.7	*n*9.316	0.711	+2.38	+16.8*
25 8 47 0	10	19 , 4	−3 37.68	+ 3 32.4	22 25 0.70	+ 3 5 43.2	*n*9.210	0.711	+2.37	+16.9*
Estimated magnitude: Sept. 25, 10.5.										
					(433) *Eros.*					
Sept.25 10 58 8	11	30 , 6	+0 56.31	+ 6 17.0	0 57 25.19	+35 36 8.9	*n*9.392	9.947	+2.95	+11.5†
25 11 20 39	12	25 , 5	+0 53.34	− 6 49.4	0 57 23.89	+35 36 23.0	*n*9.291	9.862	+2.95	+11.5†
30 9 4 39	13	20 , 4	+1 6.50	− 8 4.1	0 49 30.36	+36 33 33.0	*n*9.623	0.220	+3.03	+13.2†
Oct. 3 8 36 57	14	25 , 5	+1 26.68	− 6 40.5	0 44 6.50	+37 0 58.9	*n*9.643	0.242	+3.05	+14.2*
12 7 52 52	15	25 , 5	+1 6.21	− 4 41.0	0 26 3.99	+37 44 22.4	*n*9.632	0.185	+3.06	+17.2†
12 8 9 50	16	30 , 6	−1 15.04	− 1 39.7	0 26 2.39	+37 44 20.6	*n*9.600	0.147	+3.07	+17.1†
					[1907 *AG.*]					
Sept.29 9 28 26	17	8 , 8	+0 19.81	− 4 22.6	23 34 24.93	− 3 32 35.8	*n*9.267	0.769	+2.48	+16.3*
29 9 28 7	18	8 , 8	−0 15.76	+ 6 29.6	23 34 24.98	− 3 32 35.2	*n*9.268	0.769	+2.48	+16.3*
30 11 16 46	19	25 , 5	+1 35.70	− 7 11.8	23 33 36.19	− 3 35 30.4	8.560	0.772	+2.47	+16.3*
Oct. 2 11 10 23	20	20 , 4	+3 39.96	− 2 5.8	23 32 8.08	− 3 40 46.4	8.625	0.773	+2.47	+16.3*
5 9 26 46	21	20 , 6	−1 35.47	+ 9 1.0	23 30 2.81	− 3 48 1.8	*n*9.132	0.772	+2.47	+16.2†
8 8 47 22	22	30 , 4	+1 14.32	− 1 48.6	23 28 1.37	− 3 54 43.5	*n*9.264	0.772	+2.46	+16.1†
9 8 24 57	23	20 , 4	+1 55.15	− 6 54.3	23 27 22.76	− 3 56 45.7	*n*9.334	0.771	+2.45	+16.0†
12 9 9 59	24	30 , 6	+0 52.10	+ 3 38.1	23 25 29.50	− 4 2 35.0	*n*9.025	0.775	+2.43	+16.0†
14 11 7 54	24	24 , 8	−0 20.93	+ 0 10.2	23 24 16.47	− 4 6 2.9	9.162	0.774	+2.43	+16.0†
30 9 50 50	25	25 , 5	+2 9.44	+ 8 10.6	23 17 38.25	− 4 17 6.4	9.116	0.776	+2.28	+15.2*
Estimated magnitudes: Sept. 29, 13.5; Sept. 30, 13.5; Oct. 5, 13 7; Oct. 8, 13.5; Oct. 9, 13.5.										

1907 Wash. M.T.	*	Comp.	Δα	Δδ	App. α	App. δ	log pΔ		Red. to App. Pl.	
					(599) 1906 *VJ*.					
h m s			m s	′ ″	h m s	° ′ ″			s	″
Sept. 29 13 40 33	26	25 , 5	−1 0.41	− 5 40.6	3 4 45.42	+ 8 44 57.0	n9.023	0.645	+2.31	+10.0†
Oct. 1 12 1 37	27	18 , 6	+0 17.31	− 3 21.7	3 3 37.75	+ 8 54 16.6	n9.432	0.660	+2.36	+10.2†
5 13 7 48	28	25 , 5	+1 46.89	− 4 46.3	3 0 49.96	+ 9 13 31.4	n9.064	0.640	+2.46	+10.6†
6 12 56 7	29	30 , 6	−0 58.86	+ 0 12.3	3 0 3.89	+ 9 18 9.8	n9.113	0.640	+2.47	+10.5†
13 11 26 16	30	25 , 5	+0 26.17	+ 0 26.2	2 53 51.63	+ 9 50 32.5	n9.370	0.644	+2.62	+11.0†
Nov. 3 9 48 25	31	30 , 6	+0 19.71	+ 1 45.1	2 29 44.64	+11 25 48.2	n9.342	0.622	+2.91	+12.6†
25 11 56 54	32	25 , 5	+1 22.71	− 5 47.4	2 7 15.08	+13 9 15.9	9.388	0.604	+2.96	+14.1†

Estimated magnitudes: Sept. 29, 11.3; Oct. 1, 11.0.

1907 Wash. M.T.	*	Comp.	Δα	Δδ	App. α	App. δ	log pΔ		Red. to App. Pl.	
					(487) *Venetia*.					
Oct. 3 11 54 6	33	25 , 5	−0 15.02	− 1 43.2	1 45 9.31	− 7 12 14.7	n9.104	0.798	+2.45	+15.1†
3 12 2 48	34	30 , 6	−0 28.46	− 2 31.3	1 45 8.84	− 7 12 17.8	n9.042	0.799	+2.45	+15.1†
13 10 22 50	35	25 , 5	−0 58.87	+ 6 3.8	1 37 16.56	− 8 13 35.9	n9.323	0.800	+2.56	+14.7†
					(505) *Cava*.					
Oct. 5 10 22 41	36	25 , 5	−1 1.06	− 3 23.0	0 7 29.57	−17 44 14.4	n9.018	0.862	+2.53	+14.9*
5 10 34 35	37	25 , 5	−1 3.05	− 2 22.0	0 7 29.06	−17 44 16.1	n8.902	0.863	+2.53	+14.9*
5 10 50 38	38	25 , 5	−2 34.25	− 4 16.7	0 7 28.52	−17 44 17.9	n8.666	0.864	+2.53	+14.9*
6 11 32 53	39	25 , 5	+1 47.20	+ 1 10.7	0 6 36.42	−17 47 21.1	8.718	0.864	+2.53	+14.7*
6 11 49 1	40	25 , 5	+1 19.85	− 1 40.5	0 6 35.78	−17 47 20.8	8.934	0.863	+2.53	+14.7*
					(168) *Sibylla*.					
Oct. 9 9 43 16	41	25 , 5	+2 20.68	− 3 46.1	23 56 29.58	+ 2 36 25.7	n9.094	0.715	+2.52	+16.7*
10 11 13 47	42	20 , 4	+3 9.92	+ 0 43.9	23 55 51.67	+ 2 30 36.1	8.809	0.716	+2.51	+16.7*
10 11 33 27	43	20 , 4	+3 28.18	− 2 59.6	23 55 51.08	+ 2 30 31.2	9.013	0.716	+2.51	+16.7*
12 10 12 43	44	24 , 5	+2 24.23	−10 47.2	23 54 43.71	+ 2 19 59.7	n8.597	0.717	+2.51	+16.8*
12 10 27 55	45	25 , 5	−0 56.81	+10 13.2	23 54 43.49	+ 2 19 56.5	n7.963	0.717	+2.52	+16.7*
					(600) 1906 *UM*.					
Oct. 24 9 41 30	46	30 , 6	+2 0.25	+ 1 27.5	1 13 29.49	− 7 0 37.9	n9.211	0.795	+2.61	+14.3†
29 10 18 10	47	30 , 6	+1 38.59	− 4 31.8	1 9 48.05	− 7 20 53.9	n8.653	0.801	+2.62	+14.0*
30 10 45 4	48	25 , 5	+2 23.45	+ 4 38.6	1 9 5.49	− 7 24 22.0	8.268	0.802	+2.61	+13.9*
Nov. 4 10 16 55	49	25 , 5	+0 28.07	− 4 57.2	1 5 51.09	− 7 38 4.2	7.897	0.803	+2.61	+13.4*
4 10 26 50	50	25 , 5	−0 39.01	+ 1 28.6	1 5 50.89	− 7 38 0.7	8.445	0.803	+2.61	+13.4*
					(53) *Kalypso*.					
Oct. 25 9 30 33	51	25 , 5	+0 41.46	− 5 30.1	2 7 53.72	+ 4 3 56.1	n9.430	0.707	+2.74	+13.5*
25 9 44 25	52	25 , 5	+0 42.34	+ 8 3.2	2 7 53.60	+ 4 3 53.3	n9.392	0.705	+2.73	+13.5*
25 9 54 23	53	25 , 5	−0 3.40	+ 7 1.5	2 7 53.03	+ 4 3 49.8	n9.360	0.704	+2.71	+13.4*
25 10 4 15	54	25 , 5	−1 3.11	− 2 22.0	2 7 52.51	+ 4 3 46.0	n9.326	0.704	+2.74	+13.4*
					(471) *Papagena*.					
Oct. 24 12 28 19	55	25 , 5	+0 29.99	− 3 58.1	1 42 27.73	−14 1 44.9	9.055	0.842	+2.62	+13.4†
Nov. 7 12 19 28	56	30 , 6	−0 53.57	+ 6 57.1	1 30 58.08	−13 5 15.5	9.348	0.828	+2.64	+11.8†
7 12 37 47	57	30 , 6	−1 51.73	+ 7 22.4	1 30 57.61	−13 5 10.8	9.407	0.823	+2.64	+11.8†
					(563) *Suleika*					
Oct. 29 12 11 50	58	25 , 5	−2 49.65	−10 55.8	2 54 49.73	+ 2 4 57.4	n8.430	0.720	+2.75	+11.5†
Nov. 7 13 49 45	59	25 , 5	+0 44.72	− 3 42.9	2 46 20.71	+ 2 10 9.3	9.386	0.722	+2.84	+11.4†
7 14 7 19	60	20 , 4	+0 44.31	+ 6 24.8	2 46 20.17	+ 2 10 10.8	9.436	0.723	+2.84	+11.4†
16 11 46 13	61	25 , 5	−0 22.82	+ 0 32.4	2 38 6.05	+ 2 31 5.3	8.987	0.716	+2.89	+11.4†
16 12 1 27	62	25 , 5	+0 54.16	+ 1 45.0	2 38 5.66	+ 2 31 10.6	9.099	0.716	+2.89	+11.4†
					(63) *Ausonia*.					
Oct. 30 10 51 1	63	25 , 5	−1 36.14	− 9 37.1	2 22 22.16	+22 53 49.7	n9.095	0.395	+3.07	+12.6†
Nov. 4 10 11 10	64	19 , 4	+0 8.41	+ 5 8.1	2 17 2.77	+22 32 16.6	n9.191	0.412	+3.09	+13.4†

(192) *Nausikaa.*

1907 Wash. M.T.	⁎	Comp.	$\Delta\alpha$	$\Delta\delta$	App. α	App. δ	log $p\Delta$		Red. to App. Pl.	
h m s			m s	′ ″	h m s	° ′ ″			s	″
Nov. 4 11 10 47	65	25 , 5	−1 13.58	+ 4 35.6	4 17 11.92	+34 10 36.8	n9.482	0.125	+3.41	+ 3.0†
15 11 4 17	66	25 , 5	+1 12.94	− 8 5.5	4 5 53.05	+34 22 34.2	n9.304	9.970	+3.66	+ 5.5†
16 10 38 21	67	25 , 5	−1 54.14	− 7 18.9	4 4 45.01	+34 22 1.5	n9.394	0.032	+3.67	+ 5.4†

(14) *Irene.*

1907 Wash. M.T.	⁎	Comp.	$\Delta\alpha$	$\Delta\delta$	App. α	App. δ	log $p\Delta$		Red. to App. Pl.	
Nov. 4 12 25 24	68	25 , 5	−1 38.99	+ 7 37.4	3 40 6.95	+11 1 35.5	n8.640	0.612	+2.91	+ 8.6†
4 12 45 54	69	20 , 4	−1 26.20	−13 24.7	3 40 6.16	+11 1 32.5	n7.278	0.611	+2.92	+ 8.6†

(326) *Tamara.*

1907 Wash. M.T.	⁎	Comp.	$\Delta\alpha$	$\Delta\delta$	App. α	App. δ	log $p\Delta$		Red. to App. Pl.	
Nov. 2 10 12 23	70	25 , 5	+0 34.21	+ 3 53.6	0 53 51.82	− 1 10 53.5	7.842	0.751	+2.61	+14.9*
2 10 12 23	71	25 , 5	−0 45.72	− 0 35.2	0 53 51.78	− 1 10 52.1	7.842	0.751	+2.61	+14.8*
4 9 24 36	72	25 , 5	+0 29.33	− 5 35.6	0 51 52.44	− 0 58 49.7	n8.837	0.749	+2.60	+14.8*
4 9 33 56	73	25 , 5	−0 25.25	− 0 31.6	0 51 52.11	− 0 58 48.3	n8.700	0.749	+2.60	+14.8*

Estimated magnitudes: Nov. 2, 11.5; Nov. 4, 11.5.

(100) *Hekate.*

1907 Wash. M.T.	⁎	Comp.	$\Delta\alpha$	$\Delta\delta$	App. α	App. δ	log $p\Delta$		Red. to App. Pl.	
Nov. 2 11 18 0	74	25 , 5	−0 55.01	+ 9 46.1	3 30 51.25	+ 9 39 29.2	n9.238	0.639	+2.87	+ 9.4*
2 11 18 0	75	25 , 5	−2 3.42	+ 1 40.0	3 30 51.22	+ 9 39 29.5	n9.238	0.639	+2.87	+ 9.3*
7 11 6 32	76	25 , 5	−1 53.05	+ 1 18.6	3 26 51.76	+ 9 23 42.1	n9.176	0.640	+2.94	+ 9.3*
10 12 47 18	77	25 , 5	+2 9.79	−10 4.9	3 24 20.42	+ 9 14 36.2	8.904	0.638	+2.98	+ 9.6*

Estimated magnitudes: Nov. 2, a magnitude brighter than 12.0, as given in *B.J.* 1909; Nov. 7, 11.0.

(504) *Cora.*

1907 Wash. M.T.	⁎	Comp.	$\Delta\alpha$	$\Delta\delta$	App. α	App. δ	log $p\Delta$		Red. to App. Pl.	
Nov. 4 11 7 58	78	25 , 5	−0 15.42	− 2 15.1	2 1 19.01	−10 41 27.2	n6.872	0.824	+2.69	+12.2*
4 11 15 46	79	25 , 5	−0 20.49	+ 1 33.4	2 1 18.50	−10 41 24.8	8.180	0.824	+2.69	+12.1*

(139) *Juewa.*

1907 Wash. M.T.	⁎	Comp.	$\Delta\alpha$	$\Delta\delta$	App. α	App. δ	log $p\Delta$		Red. to App. Pl.	
Nov. 7 10 19 32	80	25 , 5	+0 53.48	+ 3 51.9	3 49 22.99	+33 42 51.4	n9.512	0.178	+3.50	+ 6.0*
13 9 3 28	81	25 , 5	−1 26.65	+ 0 38.0	3 43 11.10	+33 46 58.2	n9.611	0.304	+3.60	+ 7.2*
13 9 3 28	82	25 , 5	−3 14.88	− 9 44.1	3 43 11.04	+33 46 57.4	n9.611	0.304	+3.61	+ 7.0*
16 10 10 6	83	25 , 5	+3 19.16	+ 6 28.2	3 39 51.58	+33 46 37.5	n9.403	0.074	+3.63	+ 8.3*
16 10 10 6	84	25 , 5	+2 18.29	− 2 42.9	3 39 51.41	+33 46 38.4	n9.403	0.074	+3.64	+ 8.2*

[1907 *BE*.]

1907 Wash. M.T.	⁎	Comp.	$\Delta\alpha$	$\Delta\delta$	App. α	App. δ	log $p\Delta$		Red. to App. Pl.	
Nov. 13 10 41 0	85	25 , 5	+0 51.26	+ 7 51.4	2 39 2.78	+ 1 59 54.8	n8.771	0.721	+2.87	+11.6*
13 10 41 0	86	25 , 5	−2 30.61	+ 1 6.1	2 39 2.74	+ 1 59 55.3	n8.771	0.721	+2.88	+11.4*
14 10 54 1	87	18 , 5	+0 46.73	− 8 24.1	2 38 19.69	+ 1 58 23.2	n8.377	0.721	+2.88	+11.5†
25 9 46 16	88	25 , 5	−1 57.47	+ 2 49.9	2 31 8.90	+ 1 50 49.6	n8.766	0.722	+2.90	+10.9*
29 9 7 53	89	30 , 5	−0 1.28	+ 1 1.7	2 28 54.44	+ 1 52 11.7	n8.994	0.722	+2.89	+10.8*
Dec. 2 9 44 24	90	30 , 6	+0 37.28	+ 3 11.2	2 27 21.53	+ 1 54 40.2	6.563	0.722	+2.88	+10.6*
8 9 27 50	91	25 , 5	+2 27.53	− 0 46.6	2 24 46.12	+ 2 3 26.9	8.293	0.720	+2.86	+10.5*
11 9 35 49	91	30 , 6	+1 24.52	+ 5 29.1	2 23 43.09	+ 2 9 42.4	8.786	0.719	+2.84	+10.3*

Estimated magnitudes: Nov. 25, 13.0; Nov 29, 13.0.

[1907 *BF*.]

1907 Wash. M.T.	⁎	Comp.	$\Delta\alpha$	$\Delta\delta$	App. α	App. δ	log $p\Delta$		Red. to App. Pl.	
Nov. 13 11 37 55	92	25 , 5	+1 35.32	+ 7 4.4	2 37 48.40	+ 4 50 36.1	8.758	0.691	+2.90	+11.8*
13 11 37 55	93	25 , 5	−0 39.58	− 4 26.5	2 37 48.37	+ 4 50 35.1	8.758	0.691	+2.91	+11.8*
14 11 56 4	94	25 , 5	+1 48.30	+ 5 5.4	2 37 0.92	+ 4 47 54.0	9.010	0.692	+2.90	+11.8†
25 10 56 27	95	20 , 4	+4 22.42	+ 0 29.0	2 29 15.42	+ 4 28 48.1	8.932	0.695	+2.91	+11.7*
29 9 54 57	95	25 , 5	+2 2.26	− 1 50.4	2 26 55.26	+ 4 26 28.4	n7.079	0.695	+2.91	+11.4*
Dec. 2 10 22 41	95	25 , 5	+0 27.80	− 1 54.5	2 25 20.80	+ 4 26 24.1	8.907	0.695	+2.91	+11.2*
8 10 28 56	95	29 , 6	−2 4.57	+ 2 22.0	2 22 48.41	+ 4 30 40.3	9.158	0.696	+2.89	+10.9*
11 10 34 22	96	30 , 6	+1 49.61	− 1 25.0	2 21 50.92	+ 4 34 59.1	9.250	0.697	+2.86	+11.0*

Estimated magnitudes: Nov. 25, 12.5; Nov. 29, 12.8.

1907–8 Wash. M.T.	*	Comp.	$\Delta\alpha$	$\Delta\delta$	App. α	App. δ	log $p\Delta$		Red. to App. Pl.	
					(174) *Phaedra.*					
h m s			m s	′ ″	h m s	° ′ ″			″	s
Nov. 29 7 38 1	97	25 , 5	+0 38.43	− 8 50.0	3 44 38.77	+37 26 48.5	*n*9.668	0.281	+3.94	+ 9.2*
Dec. 6 6 55 29	98	25 , 5	+1 26.23	− 1 3.8	3 37 45.90	+36 57 16.3	*n*9.676	0.319	+3.94	+10.6*
7 6 55 0	99	15 , 3	−3 39.08	+ 0 56.8	3 36 49.59	+36 52 34.3	*n*9.670	0.308	+3.96	+10.4*
11 7 21 48	100	15 , 3	−4 5.64	− 0 46.8	3 33 14.41	+36 32 33.9	*n*9.591	0.160	+3.94	+11.2*
					[1907 *BK*]					
Dec. 2 11 10 31	101	30 , 6	+0 57.40	−10 27.0	4 16 44.31	+ 5 44 13.1	*n*8.660	0.680	+3.18	+ 5.5*
6 10 17 3	101	20 , 4	−2 21.17	−11 5.8	4 13 25.77	+ 5 43 33.9	*n*9.056	0.682	+3.21	+ 5.1*
11 11 17 52	102	18 , 6	+0 15.49	+ 4 24.4	4 9 22.88	+ 5 45 45.1	8.738	0.680	+3.23	+ 5.3*
21 8 43 42	103	30 , 4	−1 4.17	+ 2 12.3	4 2 18.52	+ 6 0 3.3	*n*9.200	0.681	+3.25	+ 4.8*
25 10 7 26	104	30 , 6	+0 51.09	− 8 48.1	3 59 51.51	+ 6 9 38.8	8.633	0.675	+3.24	+ 5.0*
31 10 2 20	105	25 , 5	−1 54.44	− 4 47.5	3 56 49.17	+ 6 27 27.5	8.934	0.673	+3.23	+ 4.5*
Jan. 3 9 13 23	106	20 , 4	+2 53.01	+ 1 24.3	3 55 35.94	+ 6 37 48.8	8.138	0.669	−0.01	− 5.8*
6 9 51 21	107	25 , 5	−3 2.77	+ 4 4.6	3 54 33.22	+ 6 49 20.5	9.062	0.669	0.00	− 5.8*
Estimated magnitudes: Dec. 2, 12.5; Dec. 6, 12.8; Dec. 31, 13.0; Jan. 3, 13.5.										
					(119) *Althaea.*					
Dec. 2 12 3 9	108	25 , 5	+2 38.82	− 3 54.8	3 56 40.53	+14 7 3.3	9.009	0.568	+3.30	+ 7.3*
2 12 3 9	109	25 , 5	−1 16.07	− 6 39.4	3 56 40.20	+14 7 0.2	9.009	0.568	+3.31	+ 7.0*
6 11 2 14	110	25 , 5	−1 1.14	+ 8 33.7	3 53 9.92	+13 51 23.4	8.227	0.568	+3.32	+ 7.1*
6 11 15 20	111	25 , 5	+0 5.43	− 3 58.8	3 53 9.40	+13 51 19.2	8.641	0.569	+3.32	+ 7.2*
					(94) *Aurora.*					
Dec. 6 8 3 17	112	25 , 5	−1 30.68	− 7 5.6	4 10 44.91	+32 16 45.7	*n*9.598	0.335	+3.86	+ 6.8*
7 8 3 6	113	20 , 4	+2 41.65	− 2 51.1	4 9 48.25	+32 14 55.9	*n*9.590	0.324	+3.86	+ 7.4*
11 8 4 41	114	25 , 5	+0 46.53	− 3 57.2	4 6 8.40	+32 6 26.4	*n*9.547	0.278	+3.87	+ 8.1*
Jan. 3 10 4 30	115	15 , 3	+4 50.24	+ 6 36.3	3 51 9.88	+31 0 12.5	9.159	0.118	0.00	+ 0.1†
5 10 5 59	116	25 , 5	+0 52.86	+ 7 39.6	3 50 30.74	+30 54 12.3	9.221	0.137	0.00	+ 0.2†
Feb. 4 10 59 45	117	25 , 5	+2 33.82	− 3 46.0	3 33 5.39	+29 36 55.0	9.680	0.529	−0.48	+ 0.5†
NOTE:—There is some uncertainty in the identification of (94) *Aurora.* Estimated magnitude: Dec. 6, 11.0.										
					(200) *Dynamene.*					
Dec. 6 9 26 33	118	30 , 6	+0 59.04	− 6 36.2	4 14 16.07	+32 42 26.5	*n*9.395	0.124	+3.88	+ 6.7*
7 8 47 24	119	20 , 4	−2 0.38	+ 1 47.7	4 13 16.81	+32 38 27.1	*n*9.502	0.212	+3.89	+ 6.7*
11 8 40 0	113	20 , 4	+2 16.11	+ 2 49.4	4 9 22.73	+32 20 36.9	*n*9.466	0.193	+3.88	+ 7.9*
Jan. 5 8 46 39	120	25 , 5	+0 5.87	+ 0 49.3	3 54 18.78	+30 10 55.8	*n*8.389	0.118	+0.02	0.0†
Feb. 4 12 0 33	121	25 , 5	+1 24.12	− 9 56.3	3 52 34.11	+29 5 58.1	9.705	0.602	−0.36	+ 0.4†
NOTE:—There is some uncertainty in the identification of (200) *Dynamene.* Estimated magnitude: Dec. 6, 10.5.										
					(536) *Merapi.*					
Dec. 25 11 4 26	122	25 , 5	+1 26.63	+ 5 11.4	6 43 24.90	+39 18 3.3	*n*9.330	9.316	+4.12	− 7.2*
27 8 50 24	123	25 , 5	+2 45.54	− 1 25.1	6 41 33.68	+39 26 28.7	*n*9.671	0.201	+4.47	− 6.6*
27 8 50 24	124	25 , 5	+1 59.07	+ 2 59.6	6 41 33.79	+39 26 25.7	*n*9.671	0.201	+4.46	− 6.7*
Jan. 2 9 58 50	125	12 , 4	−0 21.55	+ 4 36.5	6 35 35.55	+39 49 28.9	*n*9.444	9.532	+0.41	− 2.7†
2 10 5 37	126	15 , 5	−0 38.33	+ 5 59.5	6 35 35.30	+39 49 30.4	*n*9.418	9.448	+0.41	− 2.7†
9 8 41 43	127	25 , 5	+0 27.50	+ 1 52.7	6 28 50.57	+10 9 10.5	*n*9.572	9.873	+0.19	− 1.5†
					(175) *Andromache.*					
Dec. 30 10 35 32	128	15 , 3	+0 11.21	+ 7 32.4	6 27 43.59	+27 28 5.8	*n*9.238	0.279	+4.03	− 5.3*
31 8 17 43	129	25 , 5	+2 14.16	− 0 50.9	6 26 55.20	+27 28 38.8	*n*9.614	0.473	+4.05	− 5.0*
31 8 17 43	130	25 , 5	+1 41.11	− 2 10.5	6 26 55.16	+27 28 40.3	*n*9.614	0.473	+4.05	− 5.0*
Jan. 5 7 43 33	131	25 , 5	+1 11.63	+10 30.8	6 22 31.36	+27 31 10.7	*n*9.628	0.489	+0.35	− 2.6*
5 8 0 32	132	25 , 5	−1 27.27	− 5 1.2	6 22 30.74	+27 31 10.7	*n*9.604	0.461	+0.35	− 2.6*
					[1907 *BL.*]					
Dec. 31 11 20 16	133	25 , 5	+0 31.92	+ 9 50.6	6 11 22.89	+19 17 47.0	*n*8.135	0.156	+3.82	− 1.0*
Jan. 2 8 41 30	134	25 , 5	+1 3.87	+ 4 5.4	6 9 13.30	+19 13 0.6	*n*9.194	0.532	+0.29	− 3.1†
8 10 31 57	135	30 , 6	+1 32.17	0 8.2	6 1 38.16	+19 28 16.1	*n*8.637	0.464	+0.32	− 3.0*
Estimated magnitude: Dec. 31, 12.8.										

1908 Wash. M.T.	*	Comp.	Δα	Δδ	App. α	App. δ	log pΔ		Red. to App. Pl.	
					(198) Ampella.					
h m s			m s	′ ″	h m s	° ′ ″			″	s
Feb. 1 11 13 37	136	25 , 5	+0 58.58	+ 2 40.2	5 52 9.03	+19 46 20.8	9.402	0.504	+0.25	− 2.9†
3 8 47 16	137	25 , 5	+2 8.46	− 1 21.7	5 51 38.51	+19 42 32.6	n8.440	0.458	+0.23	− 2.8†
					(161) Athor.					
Jan. 3 9 53 51	138	25 , 5	−0 58.41	− 3 8.3	6 52 16.10	+37 10 12.1	n9.486	9.944	+0.39	− 3.1*
3 10 6 22	139	25 , 5	−1 0.96	− 3 22.5	6 52 15.41	+37 10 12.2	n9.446	9.882	+0.39	− 3.1*
5 8 52 46	140	25 , 5	+1 16.82	+ 9 32.3	6 49 45.51	+37 12 46.1	n9.608	0.160	+0.42	− 2.7*
5 9 7 0	141	15 , 5	−0 17.56	+ 8 49.0	6 49 44.84	+37 12 46.9	n9.579	0.104	+0.42	− 2.8*
10 7 32 6	142	18 , 6	+0 19.32	+ 5 31.8	6 43 31.78	+37 15 43.8	n9.691	0.346	+0.47	− 2.0*
					(133) Cyrene.					
Jan. 3 10 45 19	143	25 , 5	−0 45.02	− 5 22.3	7 11 27.02	+28 33 52.2	n9.328	0.264	+0.31	− 3.4*
5 9 45 27	144	25 , 5	+0 41.92	− 1 26.7	7 9 35.46	+28 34 32.4	n9.493	0.342	+0.35	− 3.2*
5 9 59 54	145	25 , 5	+1 30.52	− 4 26.7	7 9 34.77	+28 34 31.4	n9.454	0.318	+0.35	− 3.2*
10 9 55 45	146	25 , 5	−1 16.62	− 4 24.0	7 4 48.72	+28 35 0.2	n9.388	0.286	+0.41	− 2.9*
10 9 55 45	147	25 , 5	−2 5.11	− 4 8.7	7 4 48.73	+28 34 59.8	n9.388	0.286	+0.41	− 2.9*
					(532) Herculina.					
Jan. 5 11 32 11	148	25 , 5	−0 54.03	− 0 24.5	7 28 3.55	+21 49 14.1	n9.094	0.421	+0.32	− 3.2†
9 11 41 12	149	25 , 5	+0 58.86	− 0 59.2	7 24 5.26	+22 25 3.1	n8.804	0.396	+0.38	− 3.1†
9 11 58 14	150	25 , 5	+1 53.13	+ 5 34.5	7 24 4.59	+22 25 9.2	n8.431	0.393	+0.38	− 3.1†
9 12 18 25	151	25 , 5	−1 48.48	− 3 33.2	7 24 3.60	+22 25 17.3	8.223	0.392	+0.38	− 3.2†
15 9 16 40	152	25 , 5	+1 7.85	− 0 13.6	7 18 7.07	+23 17 33.5	n9.468	0.457	+0.44	− 3.2†
15 9 35 13	153	25 , 5	+0 42.73	+ 0 27.6	7 18 6.35	+23 17 40.4	n9.416	0.438	+0.44	− 3.2†
					(507) Laodica.					
Jan. 9 9 52 57	154	24 , 5	−1 45.95	− 2 29.6	6 14 23.23	+27 30 32.1	n9.181	0.267	+0.37	− 2.2†
					(121) Hermione.					
Jan. 27 9 12 41	155	25 , 5	+2 53.58	+ 3 4.5	7 28 20.03	+28 14 41.5	n9.386	0.296	+0.54	− 2.4†
27 9 36 15	156	14 , 3	+3 22.00	+ 8 42.2	7 28 19.19	+28 14 44.5	n9.289	0.264	+0.54	− 2.4†
27 9 54 3	157	15 , 3	+4 12.48	+ 8 24.6	7 28 18.55	+28 14 45.9	n9.195	0.243	+0.54	− 2.4†
30 9 47 30	158	24 , 5	+2 27.69	+ 2 7.1	7 26 4.95	+28 20 36.6	n9.148	0.232	+0.55	− 2.3†
30 9 47 30	159	25 , 5	−3 7.52	− 7 16.1	7 26 4.78	+28 20 34.2	n9.148	0.232	+0.56	− 2.4†
					[1908 *CC*.]					
Jan. 12 12 2 6	160	18 , 6	+0 21.51	− 4 28.2	8 13 51.34	+ 5 17 9.0	n8.967	0.686	+0.40	− 2.4*
14 10 37 21	161	30 , 6	+0 20.42	+ 2 16.8	8 12 8.08	+ 5 28 11.2	n9.367	0.691	+0.43	− 2.7†
19 10 25 23	162	30 , 6	+0 36.38	− 4 44.8	8 7 34.51	+ 5 59 28.6	n9.326	0.684	+0.49	− 3.4*
24 9 54 37	163	30 , 6	+1 15.97	− 3 45.0	8 2 57.33	+ 6 34 24.5	n9.349	0.679	+0.54	− 3.8†
29 10 52 7	164	25 , 5	+1 44.86	+ 2 55.5	7 58 20.04	+ 7 12 48.6	n8.836	0.663	+0.56	− 4.4†
Mar. 7 8 1 51	165	30 , 5	+0 8.84	+ 8 15.2	7 37 15.90	+12 23 13.6	n8.840	0.593	+0.31	− 4.5*
10 8 28 23	166	25 , 5	−2 10.85	− 7 15.2	7 37 8.05	+12 44 55.2	7.965	0.586	+0.28	− 4.4*
21 8 57 32	167	30 , 6	+0 13.46	+ 3 2.0	7 38 46.14	+13 56 15.5	9.183	0.577	+0.11	− 3.6*
24 8 36 38	168	15 , 3	+2 13.47	− 2 50.8	7 39 45.51	+14 13 17.3	9.123	0.570	+0.05	− 3.6†
24 8 36 38	169	15 , 3	+0 41.31	− 0 18.3	7 39 45.43	+14 13 16.8	9.123	0.570	+0.06	− 3.6†
Estimated magnitude: Jan. 12, 11.0.										
					(203) Pompeja.					
Jan. 27 11 25 8	170	25 , 5	−1 36.13	+ 3 6.0	7 10 38.55	+26 32 56.1	8.934	0.278	+0.51	− 2.4†
27 11 41 21	171	25 , 5	−0 57.67	+ 1 20.6	7 10 38.07	+26 32 56.0	9.084	0.288	+0.51	− 2.4†
NOTE: — There is some uncertainty in the identification of (203) *Pompeja*.										
					[1908 *BM*.]					
Jan. 29 7 49 23	172	30 , 6	+0 8.47	− 1 44.6	7 3 16.88	+ 8 43 21.8	n9.478	0.667	+0.48	− 4.8†
29 8 3 58	173	25 , 5	−1 18.60	− 2 4.3	7 3 16.31	+ 8 43 13.4	n9.444	0.663	+0.49	− 4.8†
30 11 22 15	174	30 , 6	+0 28.92	+ 2 21.8	7 2 13.29	+ 8 29 33.8	9.049	0.649	+0.48	− 5.0†
Feb. 19 8 14 15	175	24 , 5	−1 12.01	+ 4 3.9	6 53 3.81	+ 5 28 36.4	n8.947	0.684	+0.35	− 6.3*
22 8 17 32	176	25 , 5	−0 20.96	+ 1 8.7	6 53 13.35	+ 5 9 47.4	n8.770	0.687	+0.31	− 6.5*
Mar. 14 9 47 59	177	25 , 5	+1 3.09	− 2 4.3	7 4 35.27	+ 3 37 54.8	9.399	0.710	+0.06	− 7.3†

1908 Wash. M.T.	*	Comp.	Δα	Δδ	App. α	App. δ	log pΔ		Red. to App. Pl.	
(150) *Nuwa.*										
h m s			m s	′ ″	h m s	° ′ ″			s	″
Jan. 29 9 50 53	178	25 , 5	+2 26.53	−10 10.4	8 23 7.74	+17 57 49.5	n9.382	0.532	+0.56	− 3.8†
29 9 50 53	179	25 , 5	+1 56.72	− 9 38.6	8 23 7.55	+17 57 47.9	n9.382	0.532	+0.56	− 3.8†
NOTE: — There is some uncertainty in the identification of (150) *Nuwa.*										
(49) *Pales.*										
Feb. 1 12 27 44	180	25 , 5	−2 4.88	+ 0 55.8	7 59 59.26	+17 27 30.5	9.170	0.517	+0.57	− 3.8†
NOTE: — There is some uncertainty in the identification of (49) *Pales.*										
[1906 *VE.*]										
Feb. 1 13 20 20	181	25 , 5	−1 50.09	+ 3 4.5	8 28 29.51	+31 0 48.0	9.337	0.172	+0.66	− 3.3†
NOTE: — There is some uncertainty in the identification of *VE.*										
(454) *Mathesis.*										
Feb. 2 11 6 57	182	25 , 5	+2 16.63	+10 42.7	8 12 23.80	+30 21 1.2	n8.609	0.111	+0.64	− 2.8†
(611) 1906 *VL.*										
Feb. 4 9 38 45	183	25 , 5	+1 28.63	+ 0 52.4	8 43 32.80	− 0 0 10.5	n9.388	0.740	+0.65	− 4.4†
19 9 21 37	184	10 , 2	+1 8.79	− 1 37.6	8 32 56.46	+ 1 50 19.5	n9.177	0.723	+0.65	− 5.8*
20 10 37 15	185	25 , 5	+1 51.11	− 0 26.3	8 32 18.77	+ 1 58 46.6	7.862	0.721	+0.64	− 5.8†
20 10 37 15	186	25 , 5	−0 44.38	− 0 0.2	8 32 18.85	+ 1 58 47.3	7.862	0.721	+0.65	− 5.8†
Mar. 4 11 22 18	187	25 , 5	+0 46.94	− 1 25.3	8 26 27.70	+ 3 44 35.1	9.310	0.706	+0.54	− 6.2*
7 11 53 46	188	25 , 5	−1 26.89	+ 6 57.2	8 25 40.03	+ 4 8 35.0	9.446	0.707	+0.52	− 6.3†
24 10 11 3	189	30 , 6	+0 49.45	− 8 19.0	8 25 25.01	+ 6 10 33.4	9.342	0.683	+0.30	− 5.8†
Estimated magnitudes: Feb. 4, 12.7; March 4, 12.0.										
(90) *Antiope.*										
Feb. 6 8 16 59	190	25 , 5	+0 39.72	+ 4 0.5	8 46 34.84	+20 43 23.6	n9.583	0.561	+0.64	− 3.8†
(506) *Marion.*										
Feb. 8 10 50 46	191	20 , 4	−1 13.34	− 0 9.1	8 31 52.05	+20 31 33.0	n8.799	0.442	+0.64	− 3.6†
20 8 44 28	192	24 , 5	+0 10.54	− 4 25.7	8 21 19.01	+19 45 11.8	n9.306	0.487	+0.62	− 3.2†
20 8 59 12	193	25 , 5	−0 39.55	+ 9 10.1	8 21 18.27	+19 45 8.6	n9.239	0.479	+0.62	− 3.2†
Estimated magnitude: Feb. 8, 12.0.										
[1908 *CH.*]										
Feb. 21 10 5 6	194	10 , 2	+1 20.30	+ 4 24.5	8 17 56.41	+23 27 45.6	n8.349	0.365	+0.61	− 2.5*
22 7 43 25	195	20 , 4	+3 16.38	+ 0 15.4	8 17 21.98	+23 35 19.5	n9.477	0.454	+0.60	− 2.4*
24 8 28 31	196	25 , 5	−0 36.71	+ 4 3.1	8 16 8.60	+23 51 53.0	n9.297	0.395	+0.59	− 2.3*
28 7 29 12	197	18 , 6	+0 26.74	− 5 55.2	8 14 7.90	+24 21 47.0	n9.446	0.425	+0.56	− 2.0*
Estimated magnitudes: Feb. 22, 12.5; Feb. 24, 12.6.										
(534) *Nassoria.*										
Feb. 24 7 36 54	198	25 , 5	+1 46.41	+ 0 19.6	8 26 52.50	+22 21 39.7	n9.493	0.485	+0.61	− 2.7†
28 8 11 27	199	30 , 6	+0 58.50	− 3 33.6	8 24 43.38	+22 29 15.6	n9.334	0.435	+0.59	− 2.5*
Mar. 4 8 18 3	200	25 ; 5	+1 11.17	− 1 17.1	8 22 36.40	+22 36 11.3	n9.202	0.412	+0.54	− 2.0*
Estimated magnitudes: Feb. 28, 13.0; Mar. 4, 13.2.										
[1908 *CF.*]										
Feb. 24 9 8 11	201	25 , 5	+0 23.00	− 1 44.8	8 28 10.78	+19 17 6.9	n9.134	0.480	+0.61	− 3.3*
Mar. 3 11 10 41	202	25 , 5	+2 19.33	+ 3 10.3	8 24 17.07	+19 39 9.2	9.280	0.485	+0.51	− 2.8*
Estimated magnitudes: Feb. 24, 12.7; Mar. 3, 13.0.										
[1908 *CG.*]										
Feb. 21 10 51 35	203	25 , 5	+2 25.04	+11 37.9	8 36 44.38	+17 59 47.1	8.788	0.495	+0.62	− 3.6*
28 9 13 53	204	25 , 5	+1 19.12	+ 0 57.2	8 34 59.90	+18 18 26.8	n9.027	0.494	+0.61	− 3.5*
Mar. 4 8 52 21	205	25 , 5	−1 21.62	− 0 8.2	8 33 11.41	+18 40 8.0	n9.029	0.487	+0.58	− 3.0*
Estimated magnitudes: Feb. 24, 13.2; Feb. 28, 13.0; Mar. 4, 13.5.										

1908 Wash. M.T.	✱	Comp.	Δα	Δδ	App. α	App. δ	log pΔ		Red. to App. Pl.	
					[1908 *CL.*]					
h m s			m s	′ ″	h m s	° ′ ″			s	″
Feb. 26 12 50 3	206	25 , 5	+0 51.33	− 7 34.7	10 17 28.20	+11 24 50.5	9.047	0.610	+0.76	− 5.0*
Mar. 3 10 5 24	207	25 , 5	−2 46.79	− 1 5.1	10 12 19.36	+11 34 40.6	*n*9.208	0.612	+0.78	− 4.9*
7 10 22 15	208	20 , 4	−3 54.35	− 4 16.7	10 8 58.84	+11 40 19.1	*n*8.959	0.605	+0.78	− 4.9†
9 10 59 36	209	20 , 4	−1 10.60	− 4 50.4	10 7 21.92	+11 42 45.2	7.603	0.601	+0.77	− 4.9*
9 10 59 32	210	25 , 5	−1 21.79	− 5 41.5	10 7 21.92	+11 42 45.3	7.588	0.601	+0.77	− 4.9*
21 13 19 41	211	20 , 4	−2 40.38	+12 44.6	9 59 9.82	+11 50 14.8	9.550	0.650	+0.71	− 4.4†
24 11 53 34	212	25 , 5	+3 31.42	− 2 17.5	9 57 36.60	+11 50 9.7	9.384	0.621	+0.66	− 4.3†
27 12 40 58	212	25 , 5	+2 7.27	− 3 18.8	9 56 12.43	+11 49 8.5	9.529	0.645	+0.64	− 4.2*
Apr. 3 9 34 23	213	18 , 6	+0 18.68	− 9 31.8	9 53 50.38	+11 43 26.3	8.764	0.602	+0.57	− 3.8*
3 9 34 25	212	18 , 6	−0 14.81	− 8 59.8	9 53 50.28	+11 43 27.9	8.765	0.602	+0.57	− 3.8*
Estimated magnitudes: Feb. 26, 12.5; Mar. 3, 12.5										
					(101) *Helena.*					
Mar. 7 8 57 15	214	30 , 6	−0 59.14	+ 9 15.9	10 55 0.46	+ 6 44 57.4	*n*9.505	0.688	+0.81	− 5.3†
7 9 12 2	215	15 , 5	−0 17.01	+ 9 35.4	10 54 59.67	+ 6 44 58.2	*n*9.474	0.685	+0.81	− 5.4†
9 10 11 14	216	25 , 5	+1 46.08	+10 5.2	10 53 1.83	+ 6 50 35.5	*n*9.256	0.673	+0.82	− 5.4*
10 9 35 45	217	30 , 6	+0 1.49	+ 5 17.0	10 52 6.00	+ 6 53 14.4	*n*9.372	0.677	+0.82	− 5.5†
10 9 35 45	218	30 , 6	−3 35.87	+ 7 23.4	10 52 5.99	+ 6 53 15.0	*n*9.372	0.677	+0.82	− 5.5†
					(182) *Elsa.*					
Mar. 4 11 17 3	219	25 , 5	−2 27.84	− 6 50.0	9 30 26.73	+17 8 1.1	8.882	0.513	+0.73	− 3.9†
9 12 43 57	220	25 , 5	+3 10.26	− 6 54.9	9 27 7.03	+17 24 6.0	9.457	0.557	+0.68	− 3.6†
					(495) *Eulalia.*					
Mar. 25 10 12 45	221	20 , 4	+3 20.44	− 0 32.1	12 27 4.14	− 2 15 40.7	*n*9.364	0.758	+0.92	− 5.8*
27 13 21 47	222	25 , 5	+0 54.38	− 5 27.8	12 25 21.86	− 2 0 48.3	9.181	0.758	+0.93	− 6.0*
Apr. 2 13 49 32	223	9 , 2	−1 9.16	+ 3 20.0	12 20 37.34	− 1 19 24.9	9.401	0.750	+0.95	− 6.0†
4 11 23 11	224	24 , 5	+1 39.07	− 9 42.2	12 19 10.53	− 1 6 45.0	*n*7.868	0.750	+0.95	− 6.0†
Estimated magnitudes: Mar. 25, 12.8; Mar. 27, 12.5.										
					(622) 1906 *WP.*					
Apr. 3 10 30 21	225	29 , 6	−1 5.44	+ 4 52.9	13 0 29.26	+ 4 31 10.2	*n*9.295	0.698	+0.98	− 5.8*
4 12 18 31	226	25 , 5	−1 33.29	+ 3 36.1	12 59 32.36	+ 4 38 38.5	8.360	0.692	+0.98	− 5.8†
May 2 10 26 5	227	25 , 5	−0 33.23	− 4 8.0	12 38 13.49	+ 6 52 52.0	8.785	0.667	+0.98	− 3.8†
Estimated magnitude : Apr. 3, 14.0.										
					[1907 *XP.*]					
Apr. 3 11 34 16	228	25 , 5	+2 7.29	+ 5 57.7	13 45 16.03	− 8 13 58.5	*n*9.212	0.804	+0.96	− 5.2*
6 11 37 53	229	30 , 6	+0 19.52	− 3 10.2	13 42 51.25	− 8 5 47.0	*n*9.110	0.804	+1.00	− 5.4*
6 11 37 39	230	25 , 5	+0 7.71	− 4 45.2	13 42 51.16	− 8 5 45.8	*n*9.111	0.804	+1.00	− 5.4*
Estimated magnitude: Apr. 3, 12.8.										
					(19) *Fortuna.*					
Apr. 6 11 25 30	231	25 , 5	−0 56.67	+ 3 12.3	13 11 59.63	− 8 11 42.3	*n*8.967	0.806	+1.01	− 5.8†
6 12 10 30	232	20 , 4	−3 54.43	+ 4 4.3	13 11 57.92	− 8 11 31.8	*n*7.359	0.807	+1.01	− 5.7†
6 12 10 30	233	20 , 4	−5 32.86	+ 1 39.4	13 11 57.88	− 8 11 32.8	*n*7.359	0.807	+1.01	− 5.7†
20 10 35 7	234	25 , 5	−1 30.96	− 0 37.9	12 59 42.68	− 6 48 55.6	*n*8.769	0.788	+1.06	− 6.2†
20 10 35 7	235	25 , 5	−2 20.82	− 0 50.8	12 59 42.68	− 6 48 57.9	*n*8.769	0.788	+1.06	− 6.2†
					(387) *Aquitania.*					
Apr. 19 12 23 27	236	25 , 5	+2 23.73	+ 1 24.6	11 44 21.31	+24 30 44.5	9.487	0.440	+0.91	− 0.6†
20 11 35 18	237	20 , 4	+4 44.65	− 3 50.6	11 43 53.33	+24 31 42.1	9.354	0.391	+0.90	− 0.4†
20 12 26 29	238	25 , 5	+4 51.38	+ 0 26.8	11 43 52.27	+24 31 42.4	9.505	0.448	+0.90	− 0.4†
20 12 26 29	239	25 , 5	+3 57.19	− 2 56.8	11 43 52.14	+24 31 43.1	9.505	0.448	+0.90	− 0.4†
					[1908 *CW.*]					
May 2 9 28 16	240	25 , 5	+1 20.25	− 2 24.5	13 40 15.13	− 3 5 48.9	*n*9.242	0.766	+1.14	− 5.4†
Estimated magnitude: 13.0.										

1907–8 Wash. M.T.	✳	Comp.	Δα	Δδ	App. α	App. δ	log pΔ		Red to App.Pl.	
[1908 *CY*]										
1908 h m s			m s	′ ″	h m s	° ′ ″			s	″
May 2 12 27 53	241	30 , 6	+1 7.68	−10 35.5	14 8 10.27	− 9 42 37.4	9.097	0.815	+1.21	− 5.5†
Estimated magnitude: 13.5.										
[1908 *CZ.*]										
May 2 11 11 23	242	25 , 5	+1 59.57	+ 3 16.0	14 11 50.04	− 9 55 49.3	*n*8.556	0.819	+1.22	− 5.5†
9 13 9 12	243	25 , 5	−0 44.78	+ 2 55.1	14 6 55.55	− 9 25 14.6	9.404	0.804	+1.24	− 5.6†
June 5 10 33 4	244	25 . 5	−1 41.46	− 0 27.8	13 55 16.02	− 8 18 29.2	9.267	0.803	+1.18	− 5.0†
Estimated magnitude: May 2, 12.8										
[1908 *DA.*]										
Apr. 30 12 13 48	245	18 , 6	−0 23.56	− 3 34.0	13 23 11.70	− 0 24 51.4	9.222	0.744	+1.10	− 5.2†
May 2 13 18 28	245	20 , 4	−2 3.24	− 2 9.4	13 21 32.03	− 0 23 26.7	9.468	0.743	+1.11	− 5.1†
Estimated magnitude: Apr. 30, 13.5.										
[1908 *DB.*]										
Apr. 30 11 13 2	246	25 , 5	+3 37.94	+ 0 12.1	13 19 56.70	+ 0 50 30.5	8.744	0.732	+1.09	− 5.0†
Estimated magnitude: 13.5.										
[1908 *DC.*]										
May 23 12 32 12	247	25 , 5	+1 36.50	− 0 3.8	14 46 8.59	− 5 24 40.2	9.333	0.781	+1.34	− 4.2†
25 10 54 57	248	24 , 5	+1 50.53	− 3 19.5	14 45 3.92	− 5 10 42.2	8.666	0.785	+1.35	− 4.1†
June 1 12 17 30	249	15 , 3	−2 52.82	+11 46.4	14 41 35.84	− 4 25 31.4	9.412	0.772	+1.36	− 3.5†
5 9 17 18	250	25 . 5	−1 2.52	− 3 44.1	14 40 5.36	− 4 4 41.7	*n*8.721	0.776	+1.34	− 3.3†
Estimated magnitude: May 25, 12.7.										
(329) *Svea.*										
May 26 12 9 20	251	25 , 5	−1 34.58	+ 1 2.9	16 6 5.12	+ 3 51 7.9	8.616	0.701	+1.47	− 2.5†
28 11 40 6	252	25 , 5	−0 42.82	− 3 47.2	16 4 22.95	+ 3 59 55.8	7.286	0.700	+1.48	− 2.2†
(354) *Eleanora.*										
June 2 13 3 9	253	25 , 5	+1 8.04	+ 6 24.7	15 52 13.60	+ 7 53 5.6	9.350	0.665	+1.50	− 1.2†
6 12 31 44	254	25 . 5	+1 48.61	+12 9.6	15 49 15.60	+ 7 43 6.7	9.303	0.665	+1.51	− 0.8†
COMET 1907 *e* (MELLISH).										
1907 Oct. 15 16 51 33	255	15 , 3	+0 50.37	+ 3 18.1	8 25 33.39	− 8 39 25.2	*n*9.360	0.801	+1.02	+ 3.0†
16 16 42 30	256	30 . 6	−0 28.32	+ 0 33.1	8 22 37.50	− 8 13 51.9	*n*9.367	0.799	+1.06	+ 2.9†
17 16 19 16	257	25 . 5	+0 31.81	+ 8 43.3	8 19 32.32	− 7 47 0.7	*n*9.415	0.793	+1.11	+ 2.9†
18 16 13 53	258	24 , 5	+0 29.10	− 3 0.2	8 16 12.27	− 7 18 5.1	*n*9.410	0.789	+1.16	+ 2.7†
20 16 51 40	259	25 , 5	−0 35.67	− 0 45.8	8 8 42.28	− 6 13 2.6	*n*9.208	0.790	+1.26	+ 2.4†
21 17 12 26	260	30 , 5	−1 9.85	− 3 2.0	8 4 32.20	− 5 36 44.3	*n*9.025	0.787	+1.32	+ 2.2†
Nov. 7 14 53 40	261	25 , 5	+1 49.34	− 3 14.6	5 35 41.85	+14 26 59.3	8.682	0.559	+2.78	+ 1.1†
13 12 27 46	262	25 , 5	+3 16.25	+ 1 29.9	3 56 23.50	+23 37 7.7	6.162	0.360	+3.30	+ 7.2†
COMET 1907 *d* (DANIEL).										
Nov. 15 17 24 21	263	25 , 5	−0 51.03	− 0 23.3	13 38 2.07	− 5 43 32.0	*n*9.633	0.757	+0.48	− 2.4†
Feb. 3 17 20 43	264	25 , 5	−2 57.06	− 3 11.1	15 8 41.90	− 8 55 2.9	*n*9.042	0.810	−0.83	+ 1.7†
COMET 1907 *a* (GIACOBINI).										
Dec. 7 10 42 30	265	25 , 5	+1 46.27	− 0 33.9	3 13 35.69	+50 12 35.8	*n*8.996	0.230	+4.54	+14.5*

* Observed by HAMMOND. † Observed by FREDERICKSON.

Nos. (63), (14), (94), (200), (182), (387), (354), (168), (600), (100), (139), (174), (119), (179), (175), (161), (133), (507), (121), (203), 1908 *BM.*, (150), (49), (101), and (329) were found photographically by Mr. G. H. PETERS.

The observations of Comet 1907 *e*, on Oct. 15 and Nov. 7, and of asteriods, (471), (563), (63), (192), (14), (532), (182), (19), (387), (354), (94), on Jan. 3 and Jan. 5, and (200) on Jan. 5, were made with the 12-inch equatorial; all the other observations were made with the 26-inch equatorial

Mean Places of Comparison-Stars for the beginning of the Year.

*	α	δ	Authority	*	α	δ	Authority
	h m s	° ′ ″			h m s	° ′ ″	
1	23 39 6.20	+ 2 10 8.2	Albany, A.G. 8145	59	2 45 33.15	+ 2 13 40.8	Albany, A.G. 788
2	23 33 41.73	+ 1 44 11.2	“ “ 8128	60	2 45 33.02	+ 2 3 34.6	“ “ 787
3	23 29 37.98	+ 1 29 17.6	“ “ 8110	61	2 38 25.98	+ 2 30 21.5	“ “ 756
4	23 22 57.59	+ 1 22 28.6	½(Alb. 8081 + Nic. 5829)	62	2 37 8.61	+ 2 29 14.2	“ “ 750
5	23 22 9.91	+ 0 44 47.2	Newc's Fund.Cat. 1552	63	2 23 55.23	+23 3 14.5	Berlin (B.), A.G. 748
6	23 22 28.93	+ 0 36 41.4	Nicolajew, A.G. 5827	64	2 16 51.24	+22 26 55.1	“ “ “ 714
7	23 13 34.38	+ 0 0 59.1	“ “ 5805	65	4 18 22.09	+34 5 58.2	Leiden, A.G. 1672
8	22 24 49.08	+ 3 12 8.1	Albany, A.G. 7778	66	4 4 36.45	+34 30 34.2	“ “ 1579
9	22 29 36.55	+ 3 15 48.1	“ “ 7806	67	4 6 35.48	+34 29 15.0	“ “ 1591
10	22 28 36.01	+ 3 1 53.9	“ “ 7799	68	3 41 43.03	+10 53 49.5	Leipzig I, A.G. 1094
11	0 56 25.93	+35 29 40.4	Lund, A.G. 419	69	3 41 29.44	+11 14 48.6	“ “ “ 1092
12	0 56 27.60	+35 43 0.9	“ “ 420	70	0 53 15.00	− 1 15 2.0	Nicolajew, A.G. 180
13	0 48 20.83	+36 41 23.9	“ “ 349	71	0 54 34.89	− 1 10 31.7	“ “ 185
14	0 42 36.77	+37 7 25.2	“ “ 307	72	0 51 20.51	− 0 53 28.9	“ “ 171
15	0 24 54.72	+37 48 46.2	“ “ 176	73	0 52 14.76	− 0 58 31.5	“ “ 176
16	0 27 14.36	+37 45 43.2	“ “ 192	74	3 31 43.39	+ 9 29 33.7	Leipzig II, A.G. 1327
17	23 34 2.64	− 3 28 29.5	Strassburg, A.G. 8106	75	3 32 51.77	+ 9 37 40.2	“ “ “ 1333
18	23 34 38.26	− 3 39 21.1	“ “ 8109	76	3 28 41.87	+ 9 22 14.2	Leipzig II, A.G. 1306
19	23 31 58.02	− 3 28 34.9	“ “ 8097	77	3 22 7.65	+ 9 24 31.5	Newc's Fund Cat. 215
20	23 28 25.65	− 3 38 56.9	“ “ 8085	78	2 1 31.74	−10 39 24.3	Camb. U.S., A.G. Zones
21	23 31 35.81	− 3 57 19.0	“ “ 8096	79	2 1 36.30	−10 43 10.3	Radcliffe 1890 476
22	23 26 44.59	− 3 53 11.0	“ “ 8078	80	3 48 26.01	+33 38 53.5	Leiden, A.G. 1469
23	23 25 25.16	− 3 50 7.4	“ “ 8070	81	3 44 34.15	+33 46 13.0	“ “ 1434
24	23 24 34.97	− 4 6 29.1	“ “ 8066	82	3 46 22.31	+33 56 34.5	“ “ 1452
25	23 15 26.53	− 4 25 32.2	“ “ 8030	83	3 36 28.79	+33 40 1.0	“ “ 1386
26	3 5 43.52	+ 8 50 27.6	Leipzig II, A.G. 1186	84	3 37 29.48	+33 49 13.1	“ “ 1395
27	3 3 18.08	+ 8 57 28.1	“ “ “ 1169	85	2 38 8.65	+ 1 51 51.8	Albany, A.G. 753
28	2 59 0.61	+ 9 18 7.1	“ “ “ 1143	86	2 41 30.47	+ 1 58 37.8	“ “ 776
29	3 1 0.28	+ 9 17 47.0	“ “ “ 1155	87	2 37 30.08	+ 2 6 35.8	“ “ 752
30	2 53 22.84	+ 9 49 55.3	“ “ “ 1108	88	2 33 3.47	+ 1 47 48.8	“ “ 732
31	2 29 22.02	+11 23 50.5	“ I, “ 745	89	2 28 52.83	+ 1 50 59.2	“ “ 715
32	2 5 49.41	+13 14 49.2	“ “ “ 644[1]	90	2 26 41.37	+ 1 51 18.4	“ “ 705
33	1 45 21.88	− 7 10 46.6	Vienna, A.G. 379	91	2 22 15.73	+ 2 4 3.0	“ “ 677
34	1 45 34.85	− 7 10 1.6	“ “ 380	92	2 36 10.18	+ 4 43 19.9	“ “ 746
35	1 38 12.87	− 8 19 54.4	“ “ 354	93	2 38 25.04	+ 4 54 49.8	“ “ 755
36	0 8 28.10	−17 41 6.3	Wash'gton. A.G. Zones	94	2 35 9.72	+ 4 42 36.8	“ “ 740
37	0 8 29.58	−17 42 9.0	“ “ “	95	2 24 50.09	+ 4 28 7.4	“ “ 693
38	0 10 0.24	−17 40 16.1	“ “ “	96	2 19 58.45	+ 4 36 13.1	“ “ 672
39	0 4 46.69	−17 48 46.5	“ “ “	97	3 43 56.40	+37 35 29.3	Lund, A.G. 1959
40	0 5 13.40	−17 45 55.0	“ “ “	98	3 36 15.73	+36 58 9.5	“ “ 1910
41	23 54 6.38	+ 2 39 55.1	Albany, A.G. 8215	99	3 40 24.71	+36 51 27.1	“ “ 1941
42	23 52 39.24	+ 2 29 35.5	“ “ 8209	100	3 37 16.11	+36 33 9.5	“ “ 1919
43	23 52 20.39	+ 2 33 14.1	“ “ 8207	101	4 15 43.73	+ 5 54 34.6	Leipzig II, A.G. 1595
44	23 52 16.97	+ 2 30 30.1	“ “ 8206	102	4 9 4.16	+ 5 41 15.4	“ “ “ 1552
45	23 55 37.78	+ 2 9 26.6	“ “ 8223	103	4 3 19.44	+ 5 57 46.2	“ “ “ 1518
46	1 11 26.63	− 7 2 19.7	Vienna, A.G. 254	104	3 58 57.18	+ 6 18 21.9	“ “ “ 1503
47	1 8 6.84	− 7 16 36.1	“ “ 246	105	3 58 40.38	+ 6 32 10.5	“ “ “ 1498
48	1 6 39.43	− 7 29 14.5	“ “ 241	106	3 52 42.94	+ 6 36 30.3	“ “ “ 1454
49	1 5 20.41	− 7 33 20.4	“ “ 232	107	3 57 35.99	+ 6 45 21.7	“ “ “ 1492
50	1 6 27.29	− 7 39 42.7	“ “ 240	108	3 53 58.41	+14 10 50.8	“ I, “ 1158
51	2 7 9.52	+ 4 9 12.7	Albany, A.G. 614	109	3 57 52.96	+14 13 32.6	“ “ “ 1183
52	2 7 8.53	+ 3 55 36.6	“ “ 613	110	3 54 7.74	+13 42 42.6	“ “ “ 1159
53	2 7 53.69	+ 3 56 34.9	“ “ 618	111	3 53 0.65	+13 55 10.8	“ “ “ 1152
54	2 8 52.88	+ 4 5 54.6	“ “ 624	112	4 12 11.73	+32 23 44.5	Leiden, A.G. 1630
55	1 41 55.12	−13 58 0.2	Wash'gton, A.G. Zones	113	4 7 2.74	+32 17 39.6	“ “ 1595
56	1 31 49.01	−13 12 24.4	Camb. U.S., A.G. Zones	114	4 5 18.00	+32 10 15.5	“ “ 1583
57	1 32 46.70	−13 12 45.0	“ “ “ “	115	3 46 19.64	+30 53 36.1	“ “ 1450
58	2 57 36.63	+ 2 15 41.7	Albany, A.G. 863	116	3 49 37.88	+30 46 32.5	“ “ 1474

*	α	δ	Authority
	h m s	° ′ ″	
117	3 30 32.05	+29 40 40.5	Camb. Eng., A.G. 1746
118	4 13 13.15	+32 48 56.0	Leiden, A.G. 1636
119	4 15 13.30	+32 36 32.7	“ “ 1655
120	3 54 12.89	+30 10 6.5	½ { Leiden, 1499+ Camb. Eng. 1948 }
121	3 51 10.35	+29 15 54.0	Camb. Eng., A.G. 1926
122	6 41 53.85	+39 12 59.1	Lund, A.G. 3517
123	6 38 43 67	+39 28 0.4	“ “ 3488
124	6 39 30.26	+39 23 32.8	“ “ 3495
125	6 35 56.69	+39 44 55.1	“ “ 3449
126	6 36 13.22	+39 43 33.6	“ “ 3455
127	6 28 22.58	+40 7 19.3	½(Lund, 3371 + Bonn, 5345)
128	6 27 28.35	+27 20 38.7	Camb. Eng., A.G. 3316
129	6 24 36.99	+27 29 35.7	“ “ “ 3283
130	6 25 10.00	+27 30 55.8	“ “ “ 3291
131	6 21 19.38	+27 20 42.5	“ “ “ 3230
132	6 23 57.66	+27 36 14.5	“ “ “ 3274
133	6 10 47.15	+19 38 0.4	Berlin (A.), A.G. 2032
134	6 8 39.14	+19 38 58.3	“ “ “ 2003
135	6 3 5.67	+19 28 27.6	“ “ “ 1924
136	5 51 10.20	+19 43 43.5	“ “ “ 1771
137	5 49 29.82	+19 43 57.1	“ “ “ 1758
138	6 53 14.12	+37 13 23.5	Lund, A.G. 3615
139	6 53 15.98	+37 13 37.8	“ “ 3617
140	6 48 28.27	+37 3 16.5	“ “ 3587
141	6 50 1.98	+37 4 0.7	“ “ 3597
142	6 43 11.99	+37 10 14.0	“ “ 3526
143	7 12 11.73	+28 39 17.9	Camb. Eng., A.G. 3870
144	7 8 53.19	+28 36 2.3	“ “ “ 3834
145	7 8 3.90	+28 39 1.3	“ “ “ 3826
146	7 6 4.93	+28 39 27.1	“ “ “ 3794
147	7 6 53.43	+28 39 11.4	“ “ “ 3810
148	7 28 57.26	+21 49 41.8	Berlin (B.), A.G. 3015
149	7 23 6.02	+22 26 5.4	“ “ “ 2961
150	7 22 11.08	+22 19 37.8	“ “ “ 2952
151	7 25 51.70	+22 28 53.7	“ “ “ 2988
152	7 16 58.78	+23 17 50.3	“ “ “ 2914
153	7 17 23.18	+23 17 16.0	“ “ “ 2916
154	6 16 8.81	+27 33 3.9	Camb. Eng., A.G. 3163
155	7 25 25.91	+28 11 39.4	“ “ “ 4006
156	7 24 56.65	+28 6 4.7	“ “ “ 3997
157	7 24 5.53	+28 6 23.7	“ “ “ 3988
158	7 23 36.71	+28 18 31.8	“ “ “ 3985
159	7 29 11.74	+28 27 52.7	“ “ “ 4049
160	8 13 29.43	+ 5 21 39.6	Leipzig II, A.G. 4489
161	8 11 47.23	+ 5 25 57.1	“ “ “ 4472
162	8 6 57.64	+ 6 4 16.8	“ “ “ 4419
163	8 1 40.82	+ 6 38 13.3	“ “ “ 4355
164	7 56 34.62	+ 7 9 57.5	“ “ “ 4303
165	7 37 6.75	+12 15 2.9	“ I. “ 3052
166	7 39 18.62	+12 52 14.8	“ “ “ 3070
167	7 38 32.57	+13 53 17.1	“ “ “ 3063
168	7 37 31.99	+14 16 11.7	“ “ “ 3054
169	7 39 1.06	+14 13 38.7	“ “ “ 3067
170	7 12 14.17	+26 29 52.5	Camb. Eng., A.G. 3873
171	7 11 35.23	+26 31 37.8	“ “ “ 3866
172	7 3 7.93	+ 8 45 11.2	Leipzig II, A.G. 3531
173	7 1 34.42	+ 8 45 22.5	“ “ “ 3552
174	7 1 43.89	+ 8 27 17.0	“ “ “ 3513
175	6 54 15.47	+ 5 24 38.8	“ “ “ 3408
176	6 53 34.00	+ 5 8 45.2	“ “ “ 3394
177	7 3 32.12	+ 3 40 6.4	Albany, A.G. 2635
178	8 20 40.65	+18 8 3.7	Berlin (A.), A.G. 3329
179	8 21 10.27	+18 7 30.3	“ “ “ 3332
180	8 2 3.57	+17 26 38.5	“ “ “ 3198
181	8 30 18.94	+30 57 46.8	Leiden, A.G. 3579
182	8 10 6.53	+30 10 21.3	“ “ 3460
183	8 42 3.52	− 0 0 58.5	Nicolajew, A.G. 2700
184	8 31 47.02	+ 1 52 2.9	Albany, A.G. 3454
185	8 30 27.02	+ 1 59 18.7	“ “ 3445
186	8 33 2.58	+ 1 58 53.3	“ “ 3463
187	8 25 40.22	+ 3 46 6.6	“ “ 3399
188	8 27 6.40	+ 4 1 44.1	“ “ 3416
189	8 24 35.26	+ 6 18 58.2	Leipzig II, A.G. 4617
190	8 45 54.48	+20 39 26.9	Berlin (B.), A.G. 3562
191	8 33. 4.75	+20 31 45.7	“ “ “ 3457
192	8 21 7.85	+19 49 40.7	Berlin (A.), A.G. 3331
193	8 21 57.20	+19 36 1.7	“ “ “ 3338
194	8 13 35.50	+23 23 23.6	Berlin (B.), A.G. 3352
195	8 14 5.00	+23 35 6.5	“ “ “ 3336
196	8 16 44.72	+23 47 52.2	“ “ “ 3353
197	8 13 40.60	+24 27 44.2	“ “ “ 3332
198	8 25 5.48	+22 21 22.8	“ “ “ 3402
199	8 23 44.29	+22 32 51.7	“ “ “ 3395
200	8 21 24.69	+22 37 30.4	“ “ “ 3385
201	8 27 47.17	+19 18 55.0	Berlin (A.), A.G. 3391
202	8 21 57.20	+19 36 1.7	“ “ “ 3338
203	8 34 18.72	+17 48 12.8	“ “ “ 3450
204	8 33 40.17	+18 17 33.1	“ “ “ 3446
205	8 34 35.45	+18 40 19.2	“ “ “ 3455
206	10 16 36.11	+11 32 30.2	Leipzig I, A.G. 4001
207	10 15 5.37	+11 35 50.6	“ “ “ 3998
208	10 12 52.41	+11 44 40.7	“ “ “ 3985
209	10 8 31.75	+11 47 40.5	Yarnall, 4341
210	10 8 42.94	+11 48 31.7	“ 4344
211	10 1 49.49	+11 37 34.6	Leipzig I, A.G. 3946
212	9 54 4.52	+11 52 31.5	“ “ “ 3912
213	9 53 31.13	+11 53 1.9	“ “ “ 3908
214	10 55 58.79	+ 6 35 46.8	Leipzig II, A.G. 5657
215	10 55 15.87	+ 6 35 28.2	“ “ “ 5654
216	10 51 14.93	+ 6 40 35.7	“ “ “ 5632
217	10 52 3.69	+ 6 48 2.9	Battermann, 611
218	10 55 41.04	+ 6 45 57.1	“ 615
219	9 32 53.84	+17 14 55.0	Berlin (A.), A.G. 3877
220	9 23 56.09	+17 31 4.5	“ “ “ 3826
221	12 23 42.78	− 2 15 2.8	Nicolajew, A.G. 3421
222	12 24 26.55	− 1 55 14.5	“ “ 3422
223	12 21 45.55	− 1 22 38.9	“ “ 3413
224	12 17 30.51	− 0 56 56.8	“ “ 3401
225	13 1 33.72	+ 4 26 23.1	Albany, A.G. 4642
226	13 1 4.67	+ 4 35 8.2	“ “ 4641
227	12 38 45.74	+ 6 57 3.8	Leipzig II, A.G. 6210
228	13 43 7.78	− 8 19 51.0	Vienna, A.G. 4917
229	13 42 30.73	− 8 2 31.4	“ “ 4913
230	13 42 12.45	− 8 0 55.2	“ “ 4915
231	13 12 55.29	− 8 14 48.8	“ “ 4766
232	13 15 51.34	− 8 15 30.4	“ “ 4778
233	13 17 29.73	− 8 13 6.5	“ “ 4785
234	13 1 12.58	− 6 48 11.5	“ “ 4715
235	13 2 2.44	− 6 48 0.9	“ “ 4721
236	11 41 56.67	+24 29 20.5	Berlin (B.), A.G. 4357

*	α	δ	Authority	
	h m s	° ′ ″		
237	11 39 7.78	+24 35 33.1	Berlin (B.), A.G.	4346
238	11 38 59.99	+24 31 16.0	" " "	4345
239	11 39 54.05	+24 34 40.3	" " "	4350
240	13 38 53.74	− 3 3 19.0	Strassburg, A.G.	4919
241	14 7 1.38	− 9 31 56.4	Vienna, A.G.	5029
242	14 9 49.25	− 9 58 59.8	" "	5042
243	14 7 39.09	− 9 28 4.1	" "	5030
244	13 56 56.30	− 8 17 56.4	" "	4982
245	13 23 34.16	− 0 21 12.2	Nicolajew, A.G.	3582
246	13 16 17.67	+ 0 50 23.4	" "	3564
247	14 44 30.75	− 5 24 32.2	Strassburg, A.G.	5220
248	14 43 12.04	− 5 7 18.6	" "	5216
249	14 44 28.30	− 4 37 14.3	" "	5219
250	14 41 6.54	− 4 0 54.3	" "	5209
251	16 7 38.23	+ 3 50 7.5	Albany, A.G.	5377
252	16 5 4.29	+ 4 3 45.2	Albany, A.G.	5369
253	15 51 4.06	+ 7 46 42.1	Leipzig II, A.G.	7128
254	15 47 25.48	+ 7 30 57.9	" " "	7101
255	8 24 42.00	− 8 42 46.3	Vienna, A.G.	3273
256	8 23 4.76	− 8 14 27.9	" "	3257
257	8 18 59.40	− 7 55 46.9	" "	3214
258	8 15 42.01	− 7 15 7.6	" "	3185
259	8 9 16.69	− 6 12 19.2	$\frac{1}{2}$ {Vienna, 3123 + Strass. 3119}	
260	8 5 40.73	− 5 33 44.5	Strassburg, A.G.	3084
261	5 33 49.73	+14 30 12.8	Leipzig I, A.G.	1729
262	3 53 3.95	+23 35 30.6	Berlin (B.), A.G.	1274
263	13 38 52.62	− 5 43 6.3	Strassburg, A.G.	4920
264	15 11 39.79	− 8 51 53.5	Vienna, A.G.	5336
265	3 11 44.88	+50 12 55.2	$\frac{1}{2}$ {Camb. U.S., 1436 + Bonn 2749}	

(1) Star 32 is the N. fol. component of a double; a correction of +0s.16 in α and +1″.2 in δ has been applied to the position in the A.G Catalogue.

The star places from the Cambridge U.S. A G. Zones were furnished through the courtesy of the Director of the Observatory at that place.

OBSERVATIONS OF THE SATELLITE OF *NEPTUNE* AT THE OPPOSITION OF 1907-1908.*

MADE WITH THE 26-INCH EQUATORIAL AT THE U.S. NAVAL OBSERVATORY

By J. C. HAMMOND.

[Communicated by Captain W. J. Barnette, U.S.N., Superintendent.]

In the following observations, the settings in position-angle were made, half before and half after, the measurements in distance. The position-angle of the micrometer in measuring the distance was the mean of the first set of position-angles. The correction to the measured distance for the error in the setting of the position-circle was inappreciable in every case.

A magnifying power of 600 was used on Dec. 31, and 400 on all the other nights. Corrections have been applied for differential refraction and for the effect of the instrumental constants.

The computed positions, with which the comparisons are made, were derived from the data given in the *Connaissance des Temps*.

Date	Wash. M.T.	Position-Angle		Wash. M.T.	Distance		Comp.	O — C		Seeing
		p_o	p_c		s_o	s_c		δp	δs	
1907	h m s	°	°	h m s	″	″		°	″	
Dec. 27	9 29 47	270.51	271.33	9 29 20	17.19	16.73	6 , 6	−0.82	+0.46	Fair
31	11 45 38	19.30	21.37	11 45 8	11.72	11.30	6 , 6	−2.07	+0.42	Fair
1908										
Jan. 3	11 9 36	197.64	198.11	11 9 27	11.02	11.24	6 , 6	−0.47	−0.22	Excellent (1)
5	10 25 28	81.14	81.72	10 24 43	16.11	16.09	6 , 6	−0.58	+0.02	Excellent (2)
10	10 31 54	117.32	118.46	10 31 38	15.52	15.68	6 , 7	−1.14	−0.16	Excellent
25	9 31 46	285.53	286.64	9 31 38	16.82	16.58	6 , 6	−1.11	+0.24	Excellent
Feb. 20	9 25 59	125.53	127.63	9 25 53	14.38	14.41	6 , 7	−2.10	−0.03	Fair
24	9 35 43	259.86	260.88	9 35 52	15.95	15.95	6 , 6	−1.02	0.00	Excellent
Mar. 3	9 8 40	114.60	115.93	9 8 17	15.44	15.52	8 , 6	−1.33	−0.08	Excellent
4	9 28 49	72.94	72.52	9 29 14	15.28	15.09	8 , 8	+0.42	+0.19	Excellent
9	11 31 33	105.47	106.18	11 31 44	16.39	16.26	6 , 8	−0.71	+0.13	Excellent
21	8 5 59	100.82	101.92	8 5 27	16.39	16.35	8 , 8	−1.10	+0.04	Fair
27	7 48 44	96.25	97.42	7 46 14	16.68	16.39	11 , 10	−1.17	+0.29	Good (3)

[1] Sky hazy; satellite faint.
[2] Satellite fairly bright.
[3] Haze interrupts.

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* *From Supplement to No. 602.*

ELEMENTS AND EPHEMERIS OF PLANET 1907 *YE* (*METCALF*).*

By ARTHUR SNOW, Assistant, Nautical Almanac Office, U.S. Naval Observatory.

[Communicated by Captain W. J. Barnette, U.S. Navy, Superintendent.]

The following elements were computed from observations made by Assistant Matt Frederickson, at Washington, on March 20, April 9 and 16, 1907:

Elements.

1907 April 9.5, G.M.T.

$$\begin{array}{rl} M = & 8^\circ\ 19'\ 59''.3 \\ \omega = & 172\ \ 25\ \ 44.1 \\ \Omega = & 357\ \ 34\ \ \ \ 2.6 \\ i = & 0\ \ 20\ \ \ \ 7.2 \\ q = & 7\ \ 22\ \ \ \ 8.8 \\ \mu = & 625''.5773 \\ \log a = & 0.502484 \end{array} \qquad \left.\begin{array}{l} \omega \\ \Omega \\ i \end{array}\right\} 1908.0$$

Residuals (O — C).

	$\Delta\alpha$	$\Delta\delta$
	s	″
March 20	−.03	+0.2
April 9	+.03	−0.3
April 16	−.04	+0.3

Heliocentric Coordinates (1908.0).

$$x = r[0.000000] \sin (259^\circ\ 59'\ 46''.8 + v)$$
$$y = r[9.961447] \sin (169\ \ 59\ \ 24.3 + v)$$
$$z = r[9.605657] \sin (170\ \ \ 1\ \ 43.1 + v)$$

Ephemeris.

Gr. M.T. True Place, Mean Equinox of 1908.0.

1908	α h m s	δ ° ′ ″	log Δ	Ab. time. m s
May 27.5	18 14 53.86	−23 52 58.9	0.347829	18 29
31.5	18 12 12.20	23 54 9.1	0.344096	18 19
June 4.5	18 9 16.10	23 55 9.1	0.341138	18 12
8.5	18 6 8.45	23 55 55.2	0.339002	18 7
12.5	18 2 52.24	23 56 24.6	0.337722	18 3
16.5	17 59 30.47	23 56 34.6	0.337323	18 2
20.5	17 56 6.22	23 56 24.0	0.337823	18 4
24.5	17 52 42.77	23 55 53.4	0.339217	18 7
28.5	17 49 23.46	23 55 3.7	0.341501	18 13
July 2.5	17 46 11.52	23 53 56.3	0.344650	18 21
6.5	17 43 10.01	23 52 35.3	0.348618	18 31
10.5	17 40 21.69	−23 51 4.4	0.353356	18 43

Opposition in α, June 20, 1908

Estimated magnitude at opposition, 14.0

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* *From Supplement to No. 602.*

ELEMENTS AND EPHEMERIS OF PLANET 1907 *ZQ* (*METCALF*),

By ARTHUR SNOW, Assistant, Nautical Almanac Office.

[Communicated by Captain W. J. Barnette, U.S.N., Superintendent, U.S. Naval Observatory.]

These elements were computed from a photographic observation made by J. H. Metcalf, at Taunton, Mass., May 5, 1907, and observations made by Messrs. Hammond and Frederickson, at Washington, on May 20 and June 15, 1907.

Elements.

1907 May 20.5, G.M.T.

$$\begin{array}{rl} M = & 3^\circ\ 30'\ 23''.5 \\ \omega = & 125\ \ 45\ \ 12.0 \\ \Omega = & 103\ \ 38\ \ 18.3 \\ i = & 7\ \ 41\ \ 31.6 \\ q = & 9\ \ 19\ \ 44.3 \\ \mu = & 784''.6983 \\ \log a = & 0.436869 \end{array} \qquad \left.\begin{array}{l} \omega \\ \Omega \\ i \end{array}\right\} 1908.0$$

Residuals (O — C).

1907	α	δ
	s	″
May 5	−.01	−0.2
17	+.20	+0.2
20	−.01	−0.3
June 6	−.22	+1.9
8	−.19	+0.7
15	+.04	−0.1

Heliocentric Coordinates (1908.0).

$$x = [9.996296] r \sin (319^\circ\ 30'\ 39''.1 + v)$$
$$y = [9.968873] r \sin (232\ \ 27\ \ 47.5 + v)$$
$$z = [9.588712] r \sin (211\ \ 20\ \ 50.3 + v)$$

Ephemeris.

Gr. M.T. Mean Equinox of 1908.0

1908	α h m s	δ ° ′	log Δ	Ab. Time. m s
Aug. 28.5	0 14 16	− 9 56.9	0.29471	16 21
Sept. 1.5	0 11 39	10 23.7	0.29180	16 14
5.5	0 8 48	10 50.6	0.28982	16 10
9.5	0 5 47	11 17.0	0.28877	16 8
13.5	0 2 38	11 42.6	0.28867	16 8
17.5	23 59 23	12 6.8	0.28959	16 10
21.5	23 56 5	12 29.4	0.29152	16 14
25.5	23 52 49	12 50.1	0.29446	16 21
29.5	23 49 38	13 8.4	0.29836	16 30
Oct. 3.5	23 46 35	13 24.1	0.30314	16 41
7.5	23 43 43	13 37.0	0.30878	16 54
11.5	23 41 5	−13 46.9	0.31518	17 9

Opposition in α Sept. 21. Magnitude at opposition, 13.9

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Observations of Minor Planets and Comets, by J. C. Hammond and M. Frederickson.
Observations of the Satellite of Neptune at the Opposition of 1907–1908, by J. C. Hammond.
Elements and Ephemeris of Planet 1907 *YE* (Metcalf), by Arthur Snow.
Elements and Ephemeris of Planet 1907 *ZQ* (Metcalf), by Arthur Snow.

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CONVERGENT OF A MOVING CLUSTER IN *TAURUS*.

By LEWIS BOSS.

The phenomenon of neighboring stars moving athwart the sky with motions of the same order of magnitude and in sensibly parallel directions has been noticed many years ago. It has been demonstrated that the greater part of the stars in the *Pleiades* are moving in this manner. Numerous instances where two or three stars seem to be moving together in this manner have been pointed out. Where such stars are near enough together to constitute double-stars in the ordinary acceptation of the term this is not surprising. But the instances to which I now allude pertain to stars separated by large fractions of a degree, and even in some cases by several degrees. These stars cannot have any perceptible influence upon each other, owing to their wide mutual separations. They present, therefore, a problem of remarkable and unique interest.

For nearly twenty-five years my interest has been attracted to a system of this kind situated in the constellation *Taurus*, and embracing in its membership a part of the stars in the *Hyades*. For many years I have made unsuccessful attempts to determine a possible radiant, or convergent, for this stream. This lack of success was largely due to the fact that only the interior stars of the cluster, where the stars are relatively condensed, were recognized as indubitably belonging to the stream, the outliers having been overlooked. Toward the completion of my Preliminary General Catalogue, recently submitted for publication, it became evident that this star-stream presents the aspect of a roughly globular cluster nearly fifteen degrees in diameter, with pronounced central condensation. The opportunity to recognize this fact was offered by the relatively precise values of proper-motion which it had been possible to compute. The General Catalogue contains forty-one stars which were originally selected as probably belonging to this stream. But in the determination of the convergent it has been thought necessary to reject two of these (bracketed in Table I) as doubtful; so that the results presented in this paper are based upon the motions of thirty-nine stars enumerated in Table I. The first column of this table gives the current number in the Preliminary General Catalogue; the second column contains a designation for purposes of identification; the third column gives the magnitude of the star on CHANDLER'S normal scale (log. light ratio, 0.36); the fourth column gives the spectral type as determined at the Harvard Observatory and published in Vol. I of its Annals; the fifth and sixth columns present the approximate positions for 1875; the seventh column gives the resultant centennial motion in arc of a great circle; and the eighth column gives the position-angle of that motion.

It will be noticed that this cluster contains stars of both the first and second type, although the former are far more numerous.

The method of proceeding in the attempt to determine the convergent, approximately indicated by graphical methods at once, was very simple. Taking two values of the declination of the convergent that would probably include the final value between them, the ratio of change of declination to change of position-angle at each star was computed. Then with equations of condition, in which these ratios were introduced, the difference of declination between one of the preliminary points and that which produces the best agreement among the observed position-angles of the motions was determined.

TABLE I. OBSERVED DATA, TAURUS-CLUSTER.

No.	Desig.	Magn.	Spectral Type	R.A. 1875	Decl. 1875	μ_o	ψ
		M		h m	°	″	°
892	Pi 187	6.3	F	3 46.0	+16.95	14.8	102.9
919	Pi 215	6.2	F	53.6	+17.82	14.1	105.2
935	Pi 234	5.7	A	57.2	+ 7.85	15.9*	85.7
952	Br 562	5.9	G	4 1.9	+19.28	11.4	112.1
961	Br 566	6.0	F	4.7	+ 5.20	14.3	84.8
980	Br 572	6.5	F	8.7	+15.08	12.5	101.6
991	Br 576	5.7	A5	4 11.0	+21.27	11.2	110.4
1000	*γ Tauri*	3.8	G	12.7	+15.32	12.0	103.0
1004	Br 585	5.8	A	12.9	+13.73	12.1	103.4
1007	Br 586	5.4	A	4 13.5	+14.80	11.7	106.4
1013	Br 589	5.9	A	15.0	+13.78	11.8	105.2
1017	*δ Tauri*	4.0	K	15.7	+17.25	11.5	106.7
1018	Br 596	5.9	A2	4 16.2	+16.48	11.4	106.4
1022	Br 597	5.0	A2	16.9	+17.15	12.5	109.2
[1025	Abo 105	6.3	F	17.7	+18.75	12.4	120.5]
1026	*κ Tauri*	4.5	A3	4 17.9	+22.00	11.3	115.2
1027	Br 600	5.5	A2	18.0	+21.92	13.1	117.2
1029	Br 601	4.4	A	18.3	+17.63	11.0	103.2
1031	Br 603	6.8	A	4 18.5	+15.65	11.5	104.6
1033	*υ Tauri*	4.4	A5	18.8	+22.53	12.3	114.9
1034	Br 605	4.7	A	19.2	+15.33	11.7	103.3
1040	Pi 82	6.0	A	4 20.6	+21.33	11.8	112.4
1043	Br 611	6.1	A5	21.3	+14.47	11.1	100.9
1044	*ε Tauri*	3.6	K	21.3	+18.90	12.0	108.4
1045	*θ¹ Tauri*	4.0	K	4 21.4	+15.68	10.8	105.1
1046	*θ² Tauri*	3.5	A5	21.5	+15.60	10.7	103.5
1047	Br 614	5.2	A5	21.8	+12.77	11.1	99.3
[1051	Br 617	5.9	A	4 23.0	+15.37	10.7	96.4]
1054	Br 619	4.9	A5	23.4	+15.92	11.7	105.8
1055	Br 620	5.6	F	23.5	+15.42	11.0	105.8
1056	Br 621	5.6	A	4 23.6	+13.45	11.0	100.5
1058	Br 623	6.3	F	24.7	+15.58	10.9	106.4
1067	*ρ Tauri*	4.8	A5	26.8	+14.58	10.3	104.6
1086	Br 638	6.1	F	4 31.0	+15.78	9.4	108.0
1087	Br 639	4.5	A5	31.2	+12.25	10.4	95.5
1090	*σ² Tauri*	4.9	A	32.1	+15.67	8.4	103.7
1092	Pi 146	5.6	A	4 32.3	+ 7.62	8.2	90.7
1114	Pi 169	5.5	A	37.5	+10.92	9.8	98.2
1143	Br 666	5.2	A5	44.1	+18.63	9.1	113.2
1184	Br 694	7.0		4 52.6	+15.73	10.4	109.1
1226	Br 716	5.7	A	5 2.4	+ 9.67	7.4	94.6

* The p.m. of No. 935 is least well-determined in the list.

This process provisionally fixes a line in space along which the convergent will be found. Two points along this line were then selected so as to include the convergent, and the position-angles of these points from each of the stars were calculated and the coefficients of variation thereby deduced. By means of the resulting equations of condition the approximate point of convergence was fixed relative to the trial points selected. It is evident in this part of the computation, that the position-angles of stars along the principal axis of the stream have no appreciable weight. In fact only thirteen of the outlying stars were employed in the actual determination. Two successive approximations to the position of the convergent were computed. In view of all the elements of the determination it did not seem worth while to push it to an unwarranted degree of refinement. Before the last approximation it was seen that the deviations in position-angle for No. 1025 and No. 1051 were large, and it was decided to exclude them in the final computation. No. 1051 (Bradley 617) is a double star, — Σ 554. It is a binary and is now quite close. A rough estimate of the proper-motion of the mean of the components renders the motion of this star conformable with the stream. The proper-motion of No. 1025 (Abo 105) is less well determined than that of the general run of stars in Table I; it may possibly belong to the stream.

The result of the computation for the convergent places it in the following position for 1875:

R.A. $6^h\ 7^m.2$; Decl. $+6°\ 56'$

Another approximation would probably have given a small positive correction to each of these coordinates. The probable error of the right-ascension may be roughly estimated as, ±1°.5, and of declination, ±0°.3; though much smaller errors are indicated from the residuals, C − O.

Table II exhibits, together with some hypothetical results, some of the essential facts ascertained as a result of fixing the convergent. The first column contains the Catalogue number as given in Table I. The second column gives for each star the calculated position-angle of the adopted convergent point. This, compared with the observed position-angle of the proper-motion at the star exhibited in Table I, gives rise in the third column of Table II to the quantities appearing under "C − O," showing the differences of the direction of the observed motions from that of the convergent point. In the mean these discrepancies correspond well to those called for by the mean probable error of the proper-motions. In fact the probable error of the values of "C − O" in the third column of Table II taken indiscriminately is ±1°.8, while the mean of the probable errors of the observed position-angles is larger than this. This strongly testifies to the truth of the hypothesis that these stars are moving in parallel directions in space. This is impressively shown in the diagram, Fig. 1, of the accompanying sketch. The arrows indicate the motion of the respective stars during 50,000 years. The arrows marked with a short line across designate the rejected stars.

Table II. Taurus-Cluster, Computed Results.

No.	ψ_c	C − O	Δ	l	π
	°	°	°	Km	″
892	101.8	− 1.1	35.9	36.9	.026
919	104.2	− 1.0	34.4	37.6	.026
935	89.6	+ 3.9	33.6	38.0	.030
952	107.8	− 4.3	32.8	38.4	.022
961	84.8	0.0	30.5	39.3	.029
980	102.4	+ 0.8	30.2	39.4	.026
991	112.7	+ 2.3	31.6	38.8	.022
1000	103.4	+ 0.4	29.3	39.8	.025
1004	101.0	− 2.4	28.9	40.0	.026
1007	102.7	− 3.7	29.0	39.9	.025
1013	101.2	− 4.0	28.5	40.0	.026
1017	107.1	+ 0.4	29.1	39.8	.025
1018	106.3	− 0.1	28.7	40.0	.025
1022	107.5	− 1.7	28.8	40.0	.027
1025	(110.1)	(− 10.4)	(29.6)	(39.6)	(.026)
1026	115.3	+ 0.1	30.3	39.4	.023
1027	115.2	− 2.0	30.3	39.4	.027
1029	108.4	+ 5.2	28.6	40.0	.024
1031	105.1	+ 0.5	28.0	40.3	.025
1033	116.8	+ 1.9	30.4	39.4	.025
1034	104.6	+ 1.3	27.8	40.4	.026
1040	115.3	+ 2.9	29.5	39.7	.025
1043	103.4	+ 2.5	27.0	40.6	.025
1044	111.4	+ 3.0	28.2	40.2	.026
1045	105.7	+ 0.6	27.3	40.5	.024
1046	105.4	+ 1.9	27.3	40.5	.024
1047	100.1	+ 0.8	26.5	40.8	.026
1051	(105.4)	(+ 9.0)	(26.9)	(40.7)	(.025)
1054	106.5	+ 0.7	26.9	40.7	.027
1055	105.6	− 0.2	26.8	40.7	.025
1056	102.4	+ 1.9	26.1	41.0	.026
1058	106.0	− 0.4	26.5	40.8	.025
1067	104.6	0.0	26.2	41.0	.024
1086	107.8	− 0.2	25.0	41.3	.023
1087	100.9	+ 5.4	24.2	41.6	.026
1090	107.8	+ 4.1	24.8	41.4	.021
1092	90.2	− 0.5	23.5	41.8	.021
1114	98.3	+ 0.1	22.5	42.1	.027
1143	117.4	+ 4.2	23.4	41.9	.024
1184	113.6	+ 4.5	20.3	42.8	.031
1226	98.5	+ 3.9	16.2	43.8	.028

The fourth column, headed Δ, gives the distances in degrees of each star from the adopted convergent. The remaining columns will be explained later.

No very rigorous test of the hypothesis of uniform velocity among the members of the stream readily offers. The value of μ_o (proper-motion in a great circle) varies both with Δ and with parallax. If we take a point near the center of the cluster at Δ = 27°.5 (R.A. $4^h\ 20^m$; Decl. +15°) and draw a line in the direction of the convergent, this line may be termed the principal axis of the stream. The value of μ_o along that axis will vary proportionally with $\sin^2 \Delta$; since the component of motion that is perpendicular to the line of sight varies proportionally to $\sin \Delta$, and the apparent length of this component, as seen from the sun, also varies in proportion to $\sin \Delta$, — or inversely as the distance. It seems very probable that the shape of this cluster is roughly globular. This is a perfectly natural supposition, since the sectional outlines of nearly all well-defined clusters that we see in various parts of the sky are roughly circular. If, then, we assume the cluster to be roughly globular in form, we may assume the stars to be somewhat symmetrically arranged around any axis of the figure. Choose for the new axis of reference a diameter situated in the plane of the principal axis and of the observer, and rotated in this plane until the diameter is perpendicular to the line of sight. This will have the same position-angle as the principal axis but will be inclined to the principal axis by 62°.5 $(90° - \Delta)$. Call this the secondary axis of the cluster. We may assume, as a rough approximation, that the stars are symmetrically situated about this secondary axis. If, now, we classify the proper-motions in groups according to the values of Δ in Table II, we may suppose that, where the number of stars in a group is comparatively large, the mean of the parallaxes will be approximately the same as that of the entire cluster. Consequently, in the variation of μ_o, the element of distance will largely be eliminated, and it will be simply a question of the thwart component of the total motion, ρ. On the hypothesis of uniform direction and velocity of ρ for all the stars, μ_o varies proportionally to $\sin \Delta$. Accordingly I have arranged the stars in groups, in the order of Δ, ascertaining mean Δ and mean μ_o for each group. It appears that the mean value of μ_o in the assumed center of the cluster, as previously defined, with $\Delta_o = 27°.5$, is $11''.1$. Adopting this value of μ_o we have for the computed group values of μ_o, $11''.1 \sin \Delta$, as shown in the last column of the following table. The number of stars in group 1 being only one, and in group 5, only three, with a probable error in position-angle of about ±3° for one of them, No. 935 (least well-determined of any star in the cluster), deprives the results of those groups of special significance; but for the other groups the correspondence of observed and computed μ_o seems to be excellent.

TEST OF HYPOTHESIS OF UNIFORM VELOCITY.

Group	No. of Stars	Mean Δ	Mean μ_o Observed	Mean μ_o Computed
		°	"	"
1	1	16.2	7.4	6.7
2	7	23.4	9.4	9.5
3	10	27.0	11.0	10.9
4	17	29.7	11.9	11.9
5	3	34.6	14.9	13.6

At the point of intersection of the principal and secondary axes of the cluster as already defined, it has been found on the hypothesis of uniform velocity and direction of motion that μ_o at that point is $11''.1$, as already stated. Since the value of μ_o along the principal axis increases in proportion to $\sin^2 \Delta$, we shall have for the maximum value of μ_o, when $\Delta = 90°$:

$$\frac{1}{\sin^2 27°.5} \times 11''.1 = 52''.2$$

At that time the *Taurus*-Stream was in perihelion, approximately only 8,000 centuries (7,600) ago with a parallax for the center of about $''.05$. Furthermore, continuing the use of our hypothesis and base of computation we find that at about 65,000,000 years from the present time it may be supposed that the *Taurus*-Stream will appear as a globular cluster about 20′ in diameter and constituted largely of stars of magnitudes 9 to 12, with a well marked central condensation.

For the purpose of further deductions, let ρ be the linear centennial motion in space of a star in the cluster and ρ_s the motion in one second. Let l be the velocity in the line of sight as usually published; and let μ_s be the linear velocity per second of the ordinary component of stellar motion as we see it — the proper-motion. Then we shall have the relations: $l = \rho_s \cos \Delta = \mu_s \operatorname{cotg} \Delta$. Whenever l has been determined for one of these stars, hypothetically, ρ_s, l, μ_s, and π, the parallax, become known for this and every other star of the cluster. It happens that l has been measured by Professor KÜSTNER for three stars of this cluster— *Astroph. Jour. Vol. XXVII. No. 5.* These measurements are:

	l	Δ
		°
γ *Tauri*	+39.6 Km.	29.3
δ *Tauri*	+40.8?	29.1
ε *Tauri*	+39.4	28.2
		°
Means	39.9 Km.	28.9

Professor KÜSTNER suspects that δ *Tauri* may be subject to a periodic term in its motion, but I have thought it safest to include this star in the mean because of the comparative smallness of the discordances. The agreement of l for the three stars seems very striking. Yet these three stars are among the few in the *Taurus*-Stream that are of the second type; so that this agreement might be ascribed by some quite as much to identity of type as by others to the known facts of motion. However that may be, it will be assumed that these measures are representative of the cluster and that, when Δ is 28°.9, l is 39.9 Km. Since $\rho_s = l \sec \Delta$, we have $\rho_s = 45.6$ Km. This is the actual mean linear motion of these stars in one second, and by hypothesis this applies to all the stars in the group. Since l is proportional to $\cos \Delta$, we have now the means of computing it for each star in the cluster. The results will be found in the fifth column of Table II. It appears that

Star-Stream in Taurus. Fig. 1

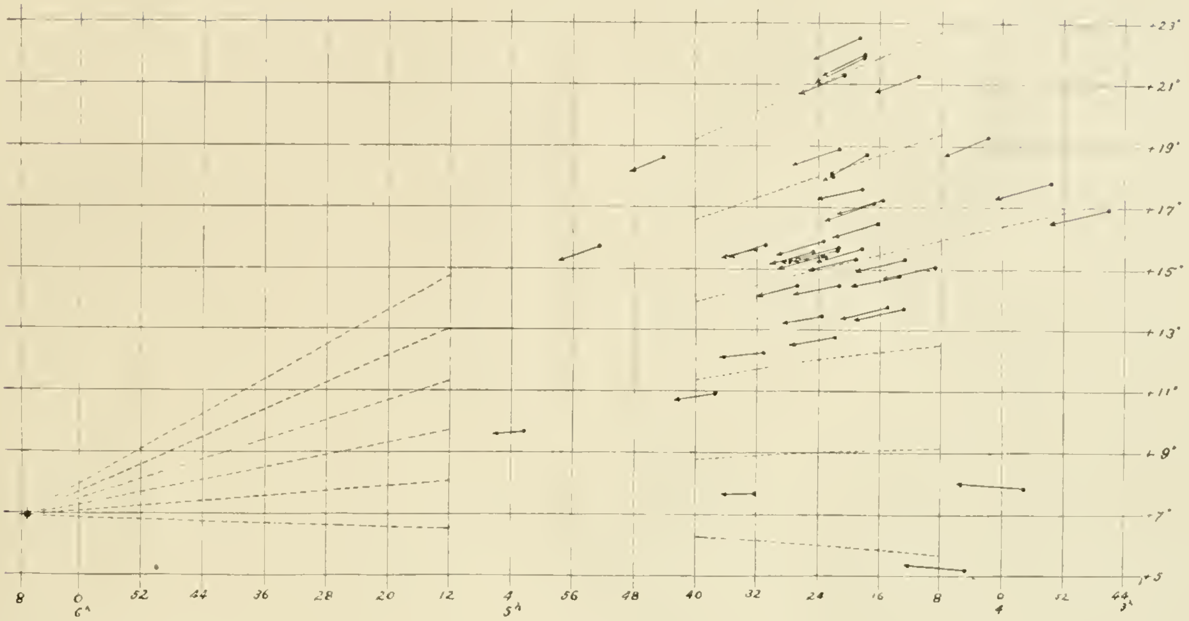
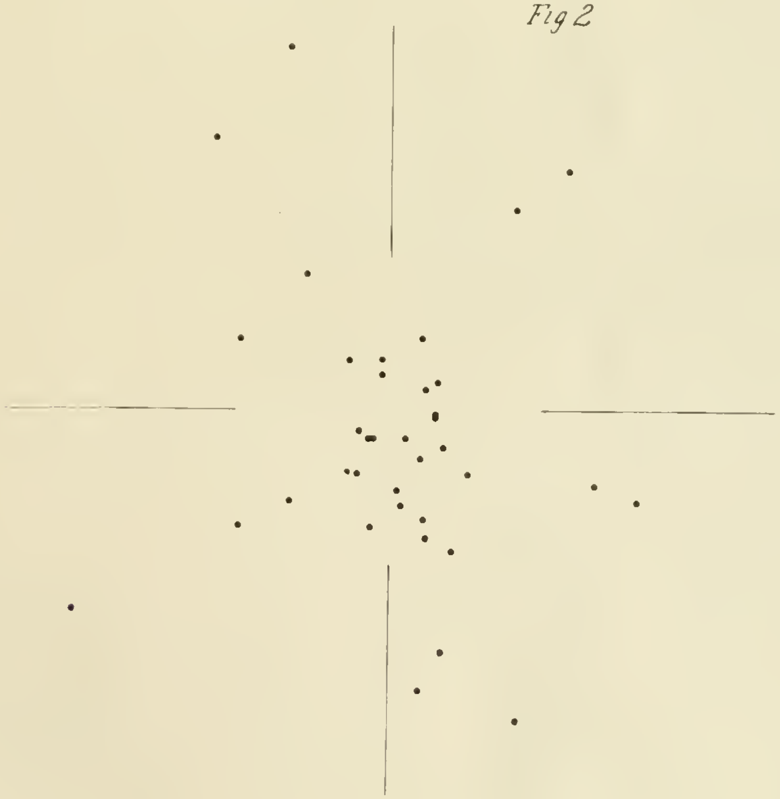


Fig 2



the predicted values of l for the various members of the stream vary from about +37 Km to nearly +44 Km. The accurate determination of l for those stars to which are here attributed extreme values of it should afford a valuable test of the hypothesis of uniformity both in direction and velocity of motion throughout the stream. Yet the varying spectral types (Table I) of these stars tend somewhat to modify expectations on this point, since it has long been a question whether the shifting of lines in the spectra of stars is altogether due to motion in the line of sight; and if not, we should expect that these additional causes of shifting might operate differently in different types of stars. The difficulty will be increased both on account of the faintness of most of the stars, as well as from the fact that the most of them have spectra that offer few well-defined lines.

Assuming, however, that all the stars are moving with a uniform velocity of 45.6 Km. per second, we can readily compute the parallaxes, π, of these stars. The results occupy the last column of Table II. The relative accuracy with which π is determined in this table depends upon the proportional accuracy attained in determination of l, as well as upon the correctness of the hypothesis of uniformity. It seems improbable that the fundamental hypothesis of this paper can ever be effectively tested by direct determination of the parallax of any of these stars, since the entire parallax itself is of the order of probable error inherent in the best determinations.

It is worth while to remark here that if we accept the parallaxes in the last column of Table II, then the mutual parallaxes between outlying stars on opposite sides of the cluster may be less than 0".10. More than thirty stars in the neighborhood of the sun have been recognized that have an estimated parallax of ".10 or more. The prevailing conditions of distance in the *Taurus*-Stream are thus probably not strikingly different from those that prevail in the vicinity of the sun. The distances from one star to another in that cluster may fairly be termed stellar in the sense in which that term is ordinarily understood. Treating of a Cosmos having such dimensions, and endeavoring to account for a hypothetical uniformity in directions and velocities of the component stars on such a scale, it is evident that we shall have to resort to hypotheses not now included in customary lines of thought. For the most part these stars are certainly too far apart to exert sensible attractions upon each other and, indeed, the effect of such attractions would be to disturb the mutual uniformity in velocities and directions. The galactic latitude of the convergent is −5°. The parallax of the cluster indicates that it is far within the boundary of the Galaxy, so that the cluster must have been for an almost inconceivable time within the limits of the Galaxy, even if its course has been sensibly rectilinear ever since it entered that system. If we suppose that the cluster was condensed from a vast nebula that originally had the present velocity and direction of the cluster, the difficulty is removed another step merely.

But whatever the speculative difficulties in connection with this phenomenon may be its substantial existence must be recognized. There are other groups of stars, though of smaller number and extent, that present the same peculiarities that are evident in the *Taurus*-Cluster. For that cluster the evidence in favor of an accurate convergence of the motions and of the remarkable agreement between observed and computed amount of angular motion, μ_o, in different parts of the cluster, is such, that one can scarcely resist the conclusion that the hypothesis of substantial uniformity both in directions and velocities of motion is essentially true. It would not be wholly surprising if future investigation should prove that one or more of these stars do not belong to the stream. This could happen as a mere coincidence of an apparent agreement in proper-motion of a star whose actual motion in space is quite different from those in the cluster; but the law of probability would not permit of many such instances in this case.

With the values of Δ and π in Table II, together with other data, it is possible to construct diagrams in which the stars of this cluster are projected on planes inclined to the tangent plane of the sky. Let us choose the plane rotated around the secondary axis of the cluster, as already defined, until it includes the observer, as well as the principal axis of the cluster. This plane will be perpendicular to the plane, tangent to the sky at the intersection of the two axes, near the center of the cluster. Projecting the stars on this plane we should have the appearance of the cluster as it would be seen from the pole of the plane of projection at the same distance from the center of the cluster as the sun now is distant from that point. The new line of sight would be perpendicular to the present line of sight. Such a diagram, rudely constructed, is presented in Fig. 2 of the accompanying sketch. The errors in location for individual stars may be large; but it appears highly probable that the general distribution of the stars may be indicated quite approximately. This indication is in favor of a roughly globular arrangement of the stars with marked central condensation.

There are many other stars which apparently belong to this stream. I have suspected about fifty of these, mostly of the magnitudes, 6.1 to 7.5. There are, doubtless, many others among the fainter stars. But some time must elapse before, for the generality of these, sufficiently accurate values of the proper-motions can be computed to enable one to decide with a fair degree of probability whether they belong to the cluster or not.

SUNSPOT OBSERVATIONS,

MADE AT BERWYN, PA., WITH A 4½-INCH REFRACTOR,

BY A. W. QUIMBY.

1907	Time	New Grs.	Total		Fac. Grs.	Def.
			Grs.	Spots		
Jan. 1	3	–	2	3	1	fair
2	8	1	3	9	2	“
4	8	1	3	17	1	“
5	8	2	5	24	2	“
6	8	–	4	7	1	v.poor
7	12	–	3	15	–	“
8	9	–	3	7	–	fair
9	12	–	3	5	–	“
10	8	–	3	7	–	“
11	8	3	5	15	4	“
12	2	–	5	10	2	“
13	9	–	5	9	2	“
14	8	–	3	11	2	“
15	8	–	3	6	2	“
16	3	–	3	7	1	“
17	8	–	3	7	1	“
18	2	–	3	4	2	“
19	8	–	1	1	2	“
20	8	1	2	3	2	“
21	9	–	1	1	1	poor
22	8	2	2	3	9	fair
23	8	–	3	18	2	“
24	2	–	1	5	–	poor
25	8	–	2	9	2	“
26	8	–	2	4	1	fair
27	8	–	1	3	2	“
28	8	–	–	–	2	poor
29	2	1	1	1	1	“
30	8	–	1	1	1	“
31	8	–	1	3	1	“
Feb. 1	1	–	1	3	–	fair
2	2	–	1	3	–	“
3	8	1	2	5	–	“
4	8	1	3	5	2	“
5	9	–	2	2	–	poor
6	2	–	1	1	1	fair
7	2	–	–	–	2	“
8	8	1	1	1	2	“
9	8	3	4	8	2	“
10	2	–	4	14	1	good
11	8	–	3	6	1	poor
12	8	1	4	6	1	“
14	9	–	4	12	1	fair
15	2	–	2	4	–	poor
16	9	–	3	8	–	fair
17	3	1	4	6	1	“
18	8	–	1	3	1	poor
19	5	–	1	3	1	“
20	9	1	2	6	1	fair
21	8	–	2	6	2	“
22	10	–	2	4	1	“
23	8	1	3	6	2	“
24	7	–	1	2	–	poor
25	9	1	2	12	2	fair
26	4	1	3	15	2	“
27	9	–	3	15	1	“
28	8	–	3	11	1	“
29	8	–	2	2	1	“

1907	Time	New Grs.	Total		Fac. Grs.	Def.
			Grs.	Spots		
Mar. 2	5	–	1	1	1	poor
3	8	–	1	1	1	“
4	8	2	2	4	3	fair
5	8	–	2	2	3	“
7	8	1	3	6	2	“
8	7	–	3	7	2	“
9	5	–	2	2	–	poor
10	8	–	2	4	1	fair
11	8	1	3	12	2	“
12	7	–	3	14	–	“
13	7	–	3	7	–	“
14	7	1	4	5	2	“
15	7	–	4	7	2	“
16	9	2	5	10	2	“
17	10	–	4	6	–	poor
18	8	1	5	10	2	fair
19	12	–	3	6	1	poor
20	8	1	4	10	1	“
21	7	–	3	8	1	fair
22	7	–	3	3	1	poor
23	7	–	2	3	1	fair
24	2	–	2	2	–	poor
25	7	–	1	1	1	“
26	7	–	–	–	1	fair
27	7	1	1	6	1	“
28	7	–	1	8	1	“
29	2	–	1	4	–	poor
30	7	–	1	4	1	fair
Apr. 1	7	1	1	3	2	poor
2	7	–	1	8	2	fair
3	5	3	4	20	2	“
4	5	1	5	28	2	“
5	7	–	5	60	3	good
6	7	–	5	56	1	“
7	7	–	5	57	1	“
8	7	–	5	53	1	“
9	7	2	7	30	2	fair
10	7	1	6	12	2	poor
11	7	1	6	9	2	“
12	7	–	4	6	2	“
13	5	–	3	4	2	“
14	7	–	1	4	1	“
15	7	–	1	6	1	“
16	5	–	1	8	2	“
17	8	1	2	8	3	“
18	12	–	2	2	–	“
19	7	2	4	5	2	“
20	7	3	7	13	3	fair
21	7	–	6	10	2	“
22	7	–	3	9	1	“
23	7	1	4	9	3	“
24	7	1	4	12	3	“
25	5	1	5	12	2	poor
26	7	–	5	17	1	good
27	7	–	5	12	2	fair
28	6	3	7	18	3	“
29	6	1	7	20	3	good
30	7	1	6	15	3	fair

1907	Time	New Grs.	Total		Fac. Grs.	Def.
			Grs.	Spots		
May 1	5	–	6	32	2	good
2	6	1	7	24	2	“
3	7	–	5	15	2	“
4	5	–	4	8	–	poor
5	6	2	6	10	2	fair
8	2	–	4	8	2	poor
9	7	2	7	22	2	good
10	7	–	6	23	2	fair
11	6	–	3	15	4	poor
12	6	–	3	12	1	“
13	6	1	4	8	2	“
14	7	–	2	4	1	fair
16	11	–	2	4	2	“
17	5	–	2	4	2	good
18	6	–	1	3	4	fair
19	11	–	1	1	–	poor
20	1	–	1	1	–	“
21	1	–	1	1	–	“
22	12	–	1	1	1	“
23	6	–	1	3	2	fair
24	6	1	2	3	3	“
25	6	1	2	3	2	“
26	6	1	2	4	3	“
27	6	1	3	7	3	“
28	6	–	3	6	3	“
29	4	–	3	4	2	“
30	5	3	6	14	2	good
31	6	–	5	23	3	“
June 1	6	1	6	33	3	“
2	7	–	5	50	3	v.good
3	7	–	4	45	3	fair
4	5	–	4	61	3	good
5	6	–	4	65	2	“
6	6	–	4	65	3	“
7	6	–	3	50	2	“
8	6	–	2	29	2	fair
9	6	1	3	12	2	“
10	6	1	3	12	3	“
11	5	–	2	4	2	“
12	6	–	2	4	3	“
13	6	–	2	3	2	“
14	6	–	1	3	2	“
15	11	–	1	1	–	poor
16	6	2	3	4	1	fair
17	6	–	3	4	1	“
18	5	3	6	16	2	good
19	6	1	6	16	2	“
20	6	–	5	14	2	fair
21	6	–	2	4	1	poor
22	6	2	3	5	2	fair
23	6	1	3	6	2	“
24	6	–	3	12	2	“
25	6	–	3	15	2	“
26	6	–	3	14	2	“
27	6	–	3	8	2	“
28	6	1	4	10	3	good
29	6	–	4	7	2	“
30	6	–	3	10	3	“

ELEMENTS AND EPHEMERIS OF PLANET 1907 *BK* (*METCALF*),

By ARTHUR SNOW, Assistant, Nautical Almanac Office.

[Communicated by Captain W. J. Barnette, U.S.N., Superintendent, U.S. Naval Observatory.]

The following elements were computed from observations made at this observatory by Mr. J. C. Hammond, on Dec. 2 and 21, 1907, and Jan. 6, 1908:

Elements.

1907 Dec. 21.71407, G.M.T.

$M = 250^\circ\ 52'\ 2''.9$

$$\left.\begin{array}{l}\omega = 49^\circ\ 0'\ 19''.2\\ \Omega = 133\ 47\ 9.9\\ i = 11\ 16\ 46.7\end{array}\right\} 1909.0$$

$q = 2\ 46\ 34.1$

$\mu = 679''.1475$

$\log a = 0.478695$

Residuals (O – C).

	α	δ
	s	″
1907 Dec. 2	0.00	–0.1
6	–0.13	+0.7
11	+0.12	–0.6
21	–0.01	0.0
25	+0.05	+1.7
31	–0.07	+1.3
1908 Jan. 3	–0.01	+1.3
6	–0.02	+0.2

Heliocentric Coordinates, 1909.0.

$x = [9.995626]\, r \sin (273^\circ\ 20'\ 59''.6 + v)$

$y = [9.984051]\, r \sin (185\ 36\ 23.8 + v)$

$z = [9.478936]\, r \sin (156\ 30\ 40.9 + v)$

Ephemeris.

Gr. M.T.	Mean Equinox of 1909.0 α	δ	log Δ	Ab. Time.
1909	h m s	° ′		m s
Jan. 29.5	10 33 18	+13 6.3	0.29490	16 22
Feb. 2.5	10 31 6	13 36.9	0.28968	16 10
6.5	10 28 37	14 8.7	0.28537	16 0
10.5	10 25 55	14 41.3	0.28206	15 53
14.5	10 23 3	15 14.1	0.27977	15 48
18.5	10 20 4	15 46.7	0.27855	15 45
22.5	10 17 2	16 18.7	0.27840	15 45
26.5	10 14 0	16 49.6	0.27934	15 47
Mar. 2.5	10 11 2	17 18.9	0.28133	15 51
6.5	10 8 11	17 46.3	0.28431	15 58
10.5	10 5 30	18 11.5	0.28825	16 7
14.5	10 3 2	18 34.3	0.29309	16 18

Opposition in α Feb. 21. Magnitude at opposition, 12.5.

OBSERVATIONS OF COMET 1908 *c* (*MOREHOUSE*).

By PHILIP FOX.

1908 Wash. M.T.	*	Comp.	$\Delta\alpha$	$\Delta\delta$	App. α	App. δ	log $p\Delta$		Red. to App. Pl.	
h m s			m s	′ ″	h m s	° ′ ″			s	″
Sept. 2 17 45 00	1	4 , 4	–3 41.25	+1 39.4	3 21 55.03	66 52 24.4	0.010	9.012	+2.80	–9.3
3 16 52 34	3	3 , 3	+6 17.20	0 20.0	3 18 41.21	67 24 57.0	0.048	0.113	+3.05	–8.6
4 15 38 59	4	5 , 5	+3 49.75	–1 16.8	3 15 15.58	67 57 28.7	0.066	0.455	+3.25	–8.5
5 20 1 16	5	5 , 5	–1 11.80	+0 3.0	3 10 29.24	68 39 49.3	9.785	n0.432	+3.35	–8.4
6 17 47 35	7	4 , 3	–2 29.00	+2 57.2	3 6 26.55	69 9 59.9	0.032	n9.800	+3.48	–8.0

Sept. 2, Comet visible in 3-inch telescope. Sept. 4, Comet difficult on account of brilliant aurora. Observations of Sept. 5 were made with the 40-inch refractor, the others with the 12-inch refractor.

*	α	δ	Authority	*	α	δ	Authority
	h m s	° ′ ″			h m s	° ′ ″	
1	3 25 33.48	66 50 54.3	B.D. 66°272 mic.comp.with *2	5	3 11 37.69	68 39 54.7	Gr.pl.: 68°1373 mic.comp.with *6
2	3 26 20.01	66 58 10.3	Christiania, A.G. 606	6	3 11 1.03	68 49 50.9	Christiania A.G. 564
3	3 12 20.96	67 25 25.5	" " 571	7	3 8 52.07	69 7 10.7	" " 559
1	3 11 22.58	67 58 54.0	" " 567				

Yerkes Observatory, 1908 Sept. 11.

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OBSERVATIONS OF MINOR PLANETS,

MADE WITH THE 26-INCH AND THE 12-INCH EQUATORIALS AT THE U.S. NAVAL OBSERVATORY.

[Communicated by Captain T. E. De Witt Veeder, U.S.N., Superintendent.]

1908 Wash. M.T.	⁎	Comp.	Δα	Δδ	App. α	App. δ	log pΔ		Red. to App. Pl.	
					(402) *Chloe.*					
h m s			m s	′ ″	h m s	° ′ ″			s	″
June 8 10 57 57	1	9 . 8	+0 11.84	− 1 21.3	17 50 16.23	− 9 51 39.4	*n*9.308	0.811	+1.65	0.0‡
11 12 8 14	2	29 , 6	+0 27.69	− 0 30.6	17 47 25.72	− 9 57 46.6	*n*8.577	0.819	+1.69	+ 0.3*
12 11 35 32	2	30 . 6	−0 27.61	− 2 42.5	17 46 30.44	− 9 59 58.4	*n*8.972	0.818	+1.71	+ 0.4*
18 10 59 14	3	25 , 5	−2 45.62	− 1 18.2	17 40 50.03	−10 15 44.3	*n*9.032	0.819	+1.79	+ 0.6*
20 11 58 54	4	25 . 5	−1 53.43	− 3 5.2	17 38 54.04	−10 22 4.0	8.510	0.822	+1.81	+ 0.6*
23 11 22 45	5	25 , 5	+0 57.65	+ 3 13.4	17 36 7.19	−10 32 1.4	*n*8.059	0.823	+1.83	+ 0.7*
28 10 32 56	6	25 , 5	−1 27.12	+ 1 34.5	17 31 38.26	−10 50 41.6	*n*8.803	0.825	+1.87	+ 1.0*
					(79) *Eurynome.*					
June 23 10 5 14	7	30 . 6	−0 43.85	− 1 27.3	16 53 17.88	−16 47 13.8	*n*8.925	0.858	+1.83	− 1.2*
26 11 34 21	8	30 . 6	−0 8.00	− 2 56.5	16 50 36.89	−16 42 34.8	9.114	0.855	+1.84	− 1.1*
					(39) *Laetitia.*					
July 1 11 47 14	9	25 . 5	−2 32.07	+ 0 3.9	18 16 6.96	−8 58 51.2	8.324	0.813	+1.92	+ 2.6*
8 12 5 13	10	25 , 5	+0 40.10	+ 0 59.7	18 10 12.41	−9 20 7.1	9.093	0.813	+1.96	+ 2.8*
					(547) *Praxedis.*					
July 17 9 55 2	11	24 , 5	−1 33.50	− 3 47.5	19 41 42.63	+5 29 33.9	*n*9.376	0.691	+2.00	+ 6.0*
17 9 55 2	12	24 , 5	−2 43.41	− 1 39.0	19 41 42.74	+5 29 34.0	*n*9.376	0.691	+2.00	+ 6.0*
					(129) *Antigone.*					
July 20 11 11 36	13	25 . 5	+1 22.30	− 1 27.1	17 35 38.72	−10 40 15.2	9.251	0.818	+1.91	+ 2.0*
20 11 26 52	14	25 , 5	+0 28.77	− 5 6.5	17 35 38.39	−10 40 20.0	9.315	0.816	+1.91	+ 2.0*
					(105) *Artemis.*					
Aug. 30 10 18 4	15	25 , 5	+2 35.17	+ 8 39.1	22 13 50.98	+ 9 44 13.9	*n*9.201	0.636	+2.28	+13.4*
31 10 56 42	16	25 , 5	−0 51.90	+ 1 47.0	22 13 0.67	+ 9 27 59.8	*n*8.868	0.634	+2.28	+13.5*
Sept. 1 11 8 2	17	18 , 6	+0 25.53	+ 1 4.9	22 12 16.24	+ 9 13 10.0	*n*8.618	0.637	+2.29	+13.6*
8 9 54 47	18	25 , 5	−1 47.15	− 5 42.9	22 7 14.35	+ 7 22 34.4	*n*9.086	0.663	+2.30	+14.5*
8 10 11 37	19	25 . 5	−1 21.90	+ 3 19.6	22 7 13.96	+ 7 22 24.5	*n*8.949	0.662	+2.29	+14.5*
					(111) *Ate.*					
Aug. 31 10 7 15	20	20 , 4	−3 3.56	−12 59.6	0 7 11.06	+ 6 59 3.4	*n*9.548	0.792	+2.19	+13.2*
Sept. 12 10 14 40	21	20 , 4	+3 13.73	+ 3 43.9	23 57 51.26	+ 6 25 13.3	*n*9.411	0.684	+2.35	+14.8*
15 10 51 33	21	25 , 5	+0 36.76	− 7 48.6	23 55 14.32	+ 6 13 41.1	*n*9.221	0.679	+2.38	+15.1*
16 9 52 42	22	25 , 5	−0 44.17	+ 0 11.5	23 54 23.90	+ 6 9 52.8	*n*9.419	0.687	+2.39	+15.3*
23 10 3 7	23	30 , 6	−2 4.75	+ 3 0.8	23 48 8.22	+ 5 38 57.7	*n*9.266	0.686	+2.43	+15.9*
30 8 35 52	24	25 , 5	−3 16.47	+11 55.2	23 42 4.29	+ 5 5 25.0	*n*9.443	0.698	+2.44	+16.2*
Oct. 6 12 29 50	25	25 . 5	+0 57.47	− 6 9.5	23 37 2.09	+ 4 34 58.8	9.342	0.699	+2.42	+16.6*

1908 Wash. M.T.	*	Comp.	Δα	Δδ	App. α	App. δ	log pΔ		Red. to App. Pl.	
					[1908 *DU*].					
h m s			m s	′ ″	h m s	° ′ ″			s	″
Sept. 1 10 14 22	26	25 , 5	+0 35.38	−0 55.2	23 10 36.85	+12 14 34.8	*n*9.408	0.619	+2.30	+13.2*
1 10 24 32	27	30 , 6	−0 45.24	−0 6.1	23 10 36.64	+12 14 35.2	*n*9.377	0.615	+2.30	+13.2*
6 10 3 59	28	25 , 5	−1 48.02	−2 15.2	23 6 31.89	+12 1 1.7	*n*9.366	0.617	+2.33	+14.2*
15 10 4 10	29	8 , 8	−0 12.45	−0 33.2	22 58 58.88	+11 22 59.7	*n*9.182	0.614	+2.37	+15.4*
16 9 10 45	29	25 , 5	−1 0.04	−5 32.8	22 58 11.29	+11 18 0.2	*n*9.383	0.628	+2.37	+15.5*
22 9 53 5	30	25 , 5	+0 47.11	+0 58.7	22 53 23.83	+10 43 26.9	*n*9.036	0.619	+2.36	+16.2*
29 8 41 17	31	25 , 5	−0 43.45	+2 26.8	22 47 3.00	+ 9 58 19.1	*n*9.259	0.636	+2.33	+16.6*
Oct. 6 11 31 38	32	25 , 5	−2 49.77	−2 0.3	22 44 29.97	+ 9 9 17.5	9.326	0.649	+2.29	+17.1*
13 10 26 57	33	25 , 5	−0 29.86	−6 51.8	22 41 49.53	+ 8 21 43.9	9.168	0.653	+2.22	+17.2*
16 9 15 44	34	25 , 5	+1 20.75	−2 4.8	22 41 5.85	+ 8 2 19.5	8.491	0.652	+2.18	+17.3*
18 10 23 10	35	25 , 5	+0 37.47	−8 34.6	22 40 44.06	+ 7 49 14.9	9.253	0.662	+2.17	+17.3*
Estimated magnitudes:	10.8 on Sept. 1; 10.3 on Sept. 15; 10.3 on Sept. 29.									
					(93) *Minerva*.					
Sept. 1 11 58 54	36	25 , 5	−2 5.16	0 44.4	22 45 10.06	−14 55 45.2	*n*7.707	0.850	+2.39	+14.0*
3 10 44 1	37	25 , 5	+2 5.69	+2 9.3	22 43 19.35	−14 58 48.3	*n*9.140	0.846	+2.41	+13.9*
6 11 0 26	38	25 , 5	+1 4.37	+2 40.3	22 40 30.30	−15 2 46.0	*n*8.878	0.849	+2.43	+13.9*
6 11 10 35	39	25 , 5	−0 43.84	−1 49.2	22 40 29.84	−15 2 46.8	*n*8.738	0.850	+2.43	+13.9*
6 11 24 16	40	25 , 5	+0 59.45	+6 30.8	22 40 29.44	−15 2 47.4	*n*8.422	0.850	+2.43	+13.9*
					(115) *Thyra*.					
Sept. 30 11 8 58	41	25 , 5	+1 0.12	+2 52.8	0 11 7.09	+23 20 2.9	*n*8.719	0.371	+2.57	+16.0*
Oct. 14 9 56 50	42	25 , 5	−3 1.68	−2 47.3	23 57 10.57	+22 42 58.2	*n*8.771	0.388	+2.55	+18.4*
					[1908 *EJ*].					
Oct. 4 12 26 48	43	25 , 5	+1 47.08	−5 10.0	1 2 53.07	+ 4 20 12.1	8.553	0.696	+2.51	+15.9*
5 8 36 8	44	25 , 5	−0 41.83	−7 43.0	1 2 0.15	+ 4 19 1.2	*n*9.559	0.713	+2.51	+16.0*
12 11 26 16	45	25 , 5	+0 43.72	+5 14.8	0 54 23.48	+ 4 9 23.6	*n*7.743	0.698	+2.55	+16.1*
15 10 23 28	46	30 , 6	+0 10.47	+4 44.7	0 51 16.41	+ 4 5 49.4	*n*9.003	0.700	+2.56	+16.3*
16 10 56 10	46	25 , 5	−0 53.36	+3 38.5	0 50 12.59	+ 4 4 43.2	*n*8.415	0.699	+2.57	+16.3*
Dec. 26 9 0 28	47	15 , 3	+2 6.96	+3 24.0	0 44 37.78	+ 8 12 11.4	9.464	0.670	+3.47	+15.1*
1909 Jan. 19 7 34 21	48	29 , 6	−0 22.58	−1 47.2	1 12 24.79	+11 47 8.9	9.420	0.626	−1.07	− 4.7*
21 8 1 48	49	10 , 2	−1 55.65	−0 46.8	1 15 12.48	+12 6 47.7	9.499	0.635	−1.05	− 4.6*
25 7 47 48	50	30 , 6	−0 15.00	+2 0.8	1 20 54.28	+12 16 17.8	9.491	0.626	−1.10	− 4.6*
Estimated magnitudes:	10.8 on Oct. 4; 13.0 on Dec. 26.									
					[*Taunton* 84].					
1908 Oct. 26 9 41 40	51	15 , 3	−5 29.36	+4 32.3	2 41 18.96	+16 11 56.4	*n*9.484	0.581	+2.83	+13.0‡
30 14 14 2	52	30 , 6	−0 38.97	−1 18.1	2 38 3.32	+15 59 31.1	9.416	0.569	+2.88	+13.6§
Nov. 1 13 14 52	53	34 , 7	+0 47.14	+1 55.6	2 36 31.05	+15 53 34.7	9.226	0.548	+2.89	+14.0§
12 9 1 59	54	17 , 6	−0 19.27	+9 6.3	2 28 12.59	+15 20 9.0	*n*9.372	0.572	+2.95	+14.5‡
15 8 58 48	55	25 , 5	+2 7.34	−0 28.2	2 26 2.42	+15 11 9.1	*n*9.333	0.569	+2.95	+14.9‡
18 8 47 50	56	25 , 5	−0 51.16	+4 6.9	2 23 58.61	+15 2 31.5	*n*9.322	0.570	+2.96	+14.9‡
22 9 20 12	57	20 , 4	+3 5.40	8 19.5	2 21 22.55	+14 51 28.4	*n*9.047	0.557	+2.95	+15.1‡
27 8 38 27	58	25 , 5	1 34.70	+0 16.2	2 18 31.14	+14 39 23.1	*n*9.175	0.565	+2.96	+15.1‡
Estimated magnitudes:	12.0 on Nov. 15; 12.0 on Nov. 18; 12.2 on Nov. 27.									
					[*Taunton* 83].					
Oct. 26 11 1 27	59	24 , 5	+2 0.95	+9 28.6	2 39 20.42	+12 36 57.2	*n*9.171	0.595	+2.78	+13.6‡
Nov. 2 13 27 10	60	55 , 11	+0 58.02	−8 22.1	2 32 32.66	+11 36 17.0	9.307	0.617	+2.77	+13.9§
12 10 19 38	61	25 , 5	+1 56.59	+1 12.3	2 23 13.92	+10 15 19.1	*n*8.864	0.624	+2.87	+14.5‡
15 10 12 42	62	29 , 6	+1 19.82	+1 1.8	2 20 37.45	+ 9 52 37.0	*n*8.763	0.628	+2.88	+14.6‡
18 9 32 52	63	25 , 5	+2 11.12	−3 50.3	2 18 11.98	+ 9 1 31.1	*n*9.038	0.636	+2.87	+14.6‡
Estimated magnitudes:	12.5 on Oct. 26; 12.8 on Nov. 12; 12.8 on Nov. 15; 12.8 on Nov. 18.									
					(28) *Bellona*.					
Dec. 18 9 43 17	64	30 , 6	+0 5.52	+0 52.6	6 14 10.01	+10 10 13.9	*n*9.479	0.617	+3.44	0.5†
*19 8 17 48	65	25 , 5	1 1.31	3 5.3	6 13 17.35	+10 12 16.1	*n*9.458	0.614	+3.46	0.6†
20 8 39 13	66	25 , 5	+1 55.64	+8 6.0	6 12 22.55	+10 11 32.1	*n*9.576	0.668	+3.47	0.1†

* The Sidereal Time of observation as recorded is diminished by one hour.

1909 Wash. M.T.	*	Comp.	Δα	Δδ	App. α	App. δ	log pΔ		Red. to App. Pl.	
					[1907 *AG*].					
h m s			m s	′ ″	h m s	° ′ ″			s	″
Jan. 21 12 37 36	67	25 , 5	+0 35.43	0 16.2	5 56 14.98	+33 45 44.1	9.560	0.232	+0.37	+ 2.8*
22 12 38 31	68	25 , 5	−2 22.31	−1 56.4	5 55 42.03	+33 42 47.8	9.571	0.249	+0.38	+ 2.8*
					(600) [1906 *UM*].					
Jan. 26 9 7 50	69	30 , 6	+0 16.09	−2 1.0	7 23 12.94	+15 40 52.9	*n*9.350	0.563	+0.51	− 0.7*
26 9 22 57	70	25 , 5	−2 38.68	−2 15.9	7 23 12.39	+15 40 54.5	*n*9.291	0.557	+0.52	− 0.7*
28 7 31 24	71	24 , 5	−0 37.82	+1 20.6	7 21 35.21	+15 51 56.6	*n*9.561	0.611	+0.51	− 0.8*
					(43) *Ariadne*.					
Feb. 20 12 45 26	72	20 , 4	−0 44.40	+7 32.1	10 22 4.42	+ 4 9 9.9	8.665	0.698	+0.74	− 3.5†
					[1907 *BF*].					
Feb. 25 14 9 13	73	10 , 2	+3 49.89	−6 38.1	9 19 31.31	+17 49 46.8	9.552	0.583	+0.75	− 1.8†
Mar. 10 8 43 47	74	24 , 5	+2 51.64	+3 40.7	9 12 1.61	+18 41 43.8	*n*9.196	0.496	+0.68	− 1.0†
11 9 2 45	75	24 , 5	+3 6.05	−5 22.1	9 11 33.96	+18 44 58.2	*n*9.040	0.486	+0.67	− 0.9†
15 10 42 50	76	29 , 6	+0 30.34	−4 23.1	9 9 56.48	+18 56 50.1	9.133	0.486	+0.66	− 0.8†
17 10 43 3	77	29 , 6	+1 59.21	−0 56.7	9 9 16.89	+19 1 55.6	9.186	0.488	+0.64	− 0.6†
					(554) *Peraga*.					
Mar. 17 11 31 15	78	25 , 5	+1 26.30	−0 41.3	11 16 42.19	+ 0 10 49.2	*n*8.002	0.738	+0.87	− 5.4*
20 10 46 10	79	25 , 5	−0 55.90	+8 37.6	11 13 57.64	+ 0 27 25.4	*n*8.850	0.736	+0.87	− 5.4*
22 11 16 7	80	25 , 5	−2 16.26	−0 7.5	11 12 9.75	+ 0 38 27.7	7.905	0.734	+0.86	− 5.4*
					(536) *Merapi*.					
Mar. 22 12 31 26	81	25 , 5	−1 16.79	−0 53.2	10 57 44.89	+33 37 21.9	9.340	0.040	+1.15	− 0.9*
25 9 33 50	82	25 , 5	+1 19.48	+8 32.9	10 55 47.15	+33 35 30.4	9.219	9.984	+1.12	− 0.2*
26 12 23 48	83	25 , 5	−4 29.94	+5 5.4	10 55 3.28	+33 34 23.3	9.384	0.072	+1.13	− 0.4*
					(202) *Chryseis*.					
Mar. 23 11 59 2	84	25 , 5	−2 4.02	−1 55.5	12 30 38.92	+ 7 19 45.8	*n*8.741	0.661	+0.93	− 6.3†
26 11 2 6	85	25 , 5	+2 28.66	+2 41.9	12 28 31.38	+ 7 40 2.9	*n*9.146	0.661	+0.95	− 6.2†
28 10 1 27	86	25 , 5	−1 51.66	+6 5.3	12 27 6.76	+ 7 52 58.0	*n*9.441	0.471	+0.98	− 6.2†
					(42) *Isis*.					
Apr. 10 9 2 0	87	20 , 4	−1 45.60	−9 6.1	13 10 29.68	+ 6 15 14.3	*n*9.500	0.692	+1.04	− 6.6†
16 12 10 33	88	30 , 6	−0 26.21	+12 41.2	13 4 36.39	+ 6 40 28.9	8.951	0.670	+1.09	− 6.2†
17 10 7 3	89	25 , 5	+1 38.71	−12 12.4	13 3 44.59	+ 6 43 39.2	*n*9.166	0.672	+1.08	− 6.1†
					(221) *Eos*.					
Apr. 15 11 46 40	90	25 , 5	+1 50.73	−2 32.7	13 51 25.32	+ 3 33 33.7	*n*8.776	0.705	+1.10	− 7.2*
16 11 49 1	91	25 , 5	+1 7.89	−5 28.2	13 50 41.34	+ 3 39 13.2	*n*8.660	0.703	+1.10	− 7.2*
22 11 58 10	92	25 , 5	−1 52.46	+6 0.0	13 46 16.99	+ 4 10 52.1	8.457	0.698	+1.14	− 6.7*
					(22) *Kalliope*.					
Apr. 16 10 53 11	93	25 , 5	2 12.19	+11 47.7	13 59 28.17	+ 1 36 12.6	*n*9.232	0.726	+1.09	− 7.4†
23 10 5 52	94	25 , 5	−3 4.24	+2 21.4	13 53 28.45	+ 1 48 14.8	*n*9.292	0.724	+1.14	− 6.9†
26 11 7 50	95	25 , 5	+2 27.20	−5 59.3	13 50 52.97	+ 1 51 44.0	*n*8.697	0.722	+1.17	− 6.7†
					[1908 *CC*].					
May 8 11 56 21	96	25 , 5	+2 31.75	+4 22.1	16 38 57.07	+ 3 52 54.8	*n*9.275	0.704	+1.23	− 7.5*
13 11 40 10	97	30 , 6	−0 34.93	+2 50.4	16 35 33.87	+ 4 26 30.9	*n*9.245	0.698	+1.33	− 7.2*
24 10 51 20	98	25 , 5	+2 28.86	+1 51.1	16 26 48.79	+ 5 18 53.7	*n*9.231	0.689	+1.50	− 5.6*
29 10 41 0	99	25 , 5	+0 21.24	−1 4.8	16 22 32.68	+ 5 31 11.5	*n*9.160	0.685	+1.53	− 5.0*
June 15 11 27 28	100	25 , 5	+0 15.47	−0 43.6	16 9 2.26	+ 5 14 25.1	9.027	0.687	+1.61	− 2.7*
1908					[1907 *ZQ*].					
Sept. 29 9 59 7	101	25 , 5	−1 53.98	−9 32.0	23 49 26.09	−13 9 12.4	9.187	0.834	+2.48	+15.0*
Oct. 2 11 39 13	102	25 , 5	+0 51.40	−1 40.5	23 47 1.97	−13 21 22.9	8.890	0.840	+2.46	+16.8*

Observers: § = A. Hall, ‡ = J. C. Hammond, * = M. Frederickson, † = J. B. Eppes.

Asteroids (105), (93), (115), (202), (554), (536), (221), (22), and [1908 *CC*] were found photographically by G. H. Peters and approximate positions were obtained from the photographic plates.

Asteroids (79), (39), (129), (115), (28), (43), (202), (42), and (22) were observed with the 12-inch equatorial. The rest were observed with the 26-inch equatorial.

It is expected that orbits of the asteroids [1908 *CL*], [1908 *EJ*], [1908 *CZ*], [1908 *DU*] and Taunton No. 84 will be computed by some of the assistants at this Observatory as volunteer work.

Mean Places of Comparison-Stars for the beginning of the Year.

*	α	δ	Authority	
	h m s	° ′ ″		
1	17 50 2.74	− 9 50 18.1	Vienna, A.G.	6028
2	17 46 56.34	− 9 57 16.3	" "	6014
3	17 43 33.86	−10 14 26.7	Camb. U.S., A.G. Zones	
4	17 40 45.66	10 18 59.4	" " " "	
5	17 35 7.71	−10 35 15.5	" " " "	
6	17 33 3.51	−10 52 17.1	" " " "	
7	16 53 59.90	−16 45 45.3	Washington, A.G.	6073
8	16 50 43.05	−16 39 37.2	" "	6052
9	18 18 37.11	8 58 57.7	Vienna, A.G.	6167
10	18 9 30.35	− 9 21 9.6	" "	6127
11	19 43 14.13	+ 5 33 15.4	Leipsic II, A.G.	9553
12	19 44 24.15	+ 5 31 7.0	" " "	9566
13	17 34 14.51	10 38 50.1	Camb. U.S., A.G. Zones	
14	17 35 7.71	−10 35 15.5	" " " "	
15	22 11 13.53	+ 9 35 21.4	Leipsic II, A.G.	11191
16	22 13 50.29	+ 9 25 59.3	" " "	11208
17	22 11 48.42	+ 9 11 51.5	" " "	11197
18	22 8 59.20	+ 7 28 2.8	" " "	11166
19	22 8 33.57	+ 7 18 50.4	" " "	11161
20	0 10 12.43	+ 7 11 49.8	Küstner	60
21	23 54 35.18	+ 6 21 14.6	Newe's Fund. Cat.	1592
22	23 55 5.68	+ 6 9 26.0	Leipsic II, A.G.	11842
23	23 50 10.54	+ 5 35 41.0	" " "	11810
24	23 45 18.32	+ 4 53 13.6	Albany, A.G.	8169
25	23 36 2.20	+ 4 40 51.7	" "	8135
26	23 9 59.17	+12 15 16.8	Leipsic I, A.G.	9254
27	23 11 19.58	+12 14 28.1	" " "	9264
28	23 8 17.58	+12 3 2.7	" " "	9243
29	22 59 8.96	+11 23 17.5	" " "	9195
30	22 52 34.36	+10 42 12.0	" " "	9151
31	22 47 44.12	+ 9 55 35.7	Leipsic II, A.G.	11431
32	22 47 17.45	+ 9 11 0.7	" " "	11426
33	22 42 17.17	+ 8 28 18.5	" " "	11393
34	22 39 42.92	+ 8 4 7.0	" " "	11377
35	22 40 4.42	+ 7 57 32.2	" " "	11378
36	22 47 12.83	−14 55 14.8	Washington, A.G.	8485
37	22 41 11.25	−15 1 11.5	" "	8458
38	22 39 23.50	−15 5 10.2	" "	8443
39	22 41 11.25	−15 1 11.5	" "	8458
40	22 39 27.56	−15 9 32.1	" "	8444
41	0 10 4.40	+23 16 54.1	Berlin B, A.G.	42
42	0 0 9.70	+22 45 27.1	" " "	9203
43	1 1 3.48	+ 4 25 6.2	Albany, A.G.	286
44	1 2 39.47	+ 1 26 28.2	" "	299
45	0 53 37.21	+ 4 3 52.7	" "	242
46	0 51 3.38	+ 4 0 48.4	" "	231
47	0 42 27.35	+ 8 8 32.3	Leipsic II, A.G	260
48	1 12 48.44	+11 19 0.8	" I. "	353
49	1 17 9.18	+12 7 39.1	" " "	384
50	1 21 10.38	+12 11 21.6	" " "	407
51	2 46 45.49	−16 7 11.1	Berlin A, A.G.	771
52	2 38 39.41	+16 0 35.6	B.D. + 15°377 compared with Berlin A. A.G. 771. $\Delta\alpha = -8^m\ 6^s.04$ $\Delta\delta = -6'\ 35''.0.$	
53	2 35 41.02	+15 48 25.1	Berlin A. A.G.	721
54	2 28 28.91	+15 10 48.2	1 [Berlin A, A.G. 699] 2 [Leipsic I. A.G. 742]	
55	2 23 52.13	+15 11 22.4	Leipsic I, A.G.	722
56	2 24 49.81	+14 58 9.7	" " "	725
57	2 18 14.20	+14 59 32.8	" " "	689
58	2 20 2.88	+14 38 51.8	Küstner	1013
59	2 37 16.69	+12 27 15.0	Leipsic I, A.G.	789
60	2 31 31.87	+11 44 25.2	" " "	758
61	2 21 14.46	+10 13 52.3	Leipsic II, A.G.	907
62	2 19 14.75	+ 9 51 20.6	" " "	892
63	2 15 57.99	+ 9 35 6.8	" " "	873
64	6 14 1.05	+10 39 21.8	Leipsic I, A.G.	2165
65	6 14 15.20	+10 45 22.3	" " "	2171
*66	6 10 23.44	+10 36 26.8	" " "	2126
67	5 55 39.18	+33 45 57.5	Leiden, A.G.	2402
68	5 58 3.96	+33 44 41.4	" "	2423
69	7 22 56.34	+15 42 54.6	Berlin A, A.G.	2850
70	7 25 50.55	+15 43 11.1	" " "	2874
71	7 22 12.52	+15 50 36.8	Berlin A, A.G.	2844
72	10 22 48.08	+ 4 1 41.3	Albany, A.G.	4045
73	9 15 40.67	+17 56 26.7	Berlin A, A.G.	3775
74	9 9 9.29	+18 38 4.1	" " "	3732
75	9 8 27.24	+18 50 21.2	B.D. + 19°2177 compared with Küstner (1885.0) 300 $\Delta\alpha = +2^m\ 16^s.91$ $\Delta\delta = -5'\ 46''.1.$	
76	9 9 25.48	+19 1 14.0	Berlin A, A.G.	3735
77	9 7 17.04	+19 2 52.9	" " "	3721
78	11 15 15.02	+ 0 11 35.9	Nicolajew, A.G.	3226
79	11 14 52.67	+ 0 18 53.2	" "	3225
80	11 14 25.15	+ 0 38 40.6	" "	3222
81	10 59 0.53	+33 38 16.0	Leiden, A.G.	4348
82	10 54 26.55	+33 26 57.7	" "	4328
83	10 59 32.09	+33 29 18.3	" "	4351
84	12 32 42.01	+ 7 21 47.6	Leipsic II, A.G.	6179
85	12 26 1.77	+ 7 37 27.2	" " "	6146
86	12 28 57.44	+ 7 46 58.9	" " "	6164
87	13 12 14.24	+ 6 24 27.0	" " "	6363
88	13 5 1.51	+ 6 27 53.9	" " "	6334
89	13 2 4.80	+ 6 55 57.7	" " "	6321
90	13 49 33.49	+ 3 36 13.6	Albany, A.G.	4816
91	13 49 32.35	+ 3 44 48.6	" "	4815
92	13 48 8.31	+ 4 4 58.8	" "	4808
93	14 1 39.27	+ 1 24 32.3	" "	4873
94	13 56 31.55	+ 1 46 0.3	" "	4838
95	13 48 24.60	+ 1 57 50.0	" "	4810
96	16 36 21.09	+ 3 48 40.2	" "	5518
97	16 36 7.47	+ 4 23 47.7	" "	5517
98	16 24 18.43	+ 5 17 8.2	Leipsic II, A.G.	7345
99	16 22 9.91	+ 5 32 21.3	" " "	7329
100	16 8 45.18	+ 5 15 11.4	" " "	7229
101	23 51 17.59	−12 59 55.4	Camb. U.S., A.G	Zones
102	23 46 11.11	−13 19 59.2	" " "	"

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*This is the position of the south preceding component.

VISUAL OBSERVATIONS OF HALLEY'S COMET,

MADE WITH THE 40-INCH REFRACTOR OF THE YERKES OBSERVATORY,

By E. E. BARNARD.

The following observations of HALLEY'S Comet were made with the micrometer of the 40-inch telescope. It has been an easy object with the large telescope and the measures should be good. I have prepared the notes to accompany the measures as they may be useful in future returns. In the first measures, it was much brighter and easier to observe than the TEMPEL-SWIFT Periodic Comet when seen with the same telescope in the last of December, 1908 (*A.N.* 4306).

It is not possible to measure exactly the diameter of such an object, but careful settings of the micrometer wires will be much better than any estimate of its diameter, and will closely represent its visible dimensions. I have therefore endeavored to get as exact a value for the diameter as possible at the various observations.

The observed positions of the comet are:

1909	*C.S.T.	$\Delta\alpha$	$\Delta\delta$	Comp.	α Appt.	δ Appt.	Reduced to Appt.		*
	h m s	m s	′ ″		h m s	° ′ ″	s	″	
Sept. 17	15 2 22	+0 22.55	+3 28.9	24 , 9	6 19 0.90	+17 9 0.8	+1.12	+ 5.3	1
24	14 22 33		+0 39.4	9		+17 6 11.2		+ 5.2	1
24	14 34 9	+0 18.99		10	6 18 57.58		+1.36		1
26	15 21 50		−0 10.7	8		+17 5 21.1		+ 5.2	1
26	15 47 59	+0 5.65		8	6 18 44.30		+1.42		1
Oct. 17	16 48 32		+0 37.5	8		+16 57 48.1		+ 5.2	2
17	16 56 50	−0 16.23		14	6 9 11.63		+2.12		2
19	14 7 47	−1 56.83	+0 3.1	20 , 8	6 7 30.99	+16 57 13.7	+2.08	+ 5.1	2
26	14 19 46		−0 29.9	3		+16 55 0.0		+ 5.7	3
26	14 33 51	+1 40.26		12	5 59 40.71		+2.43		3
26	17 0 10	+1 32.13	−0 32.7	16 , 6	5 59 32.58	+16 54 57.2	+2.43	+ 5.7	3
Nov. 14	13 1 25	+1 47.92	+4 18.1	28 , 8	5 22 41.14	+16 41 37.2	+3.06	+ 7.3	4
28	9 30 51	−0 38.01	−2 58.4	22 , 8	4 37 16.40	+16 4 44.2	+3.36	+10.0	5
30	8 46 12	−0 50.92	−1 50.7	24 , 8	4 29 33.96	+15 55 49.1	+3.39	+10.5	6

*Central Standard Time, six hours slow of Greenwich time.

Mean Places of Comparison Stars.

*	α 1909.0	δ 1909.0	Authority
	h m s	° ′ ″	
1	6 18 37.23	+17 5 26.6	Berlin, A.G.C. 2122
2	6 9 25.74	+16 57 5.4	10½ Mag. compared with Berlin, A.G.C. 2018
3	5 57 58.02	+16 55 24.2	Berlin, A.G.C. 1867
4	5 20 50.16	+16 37 11.8	Berlin, A.G.C. 1517
5	4 37 51.05	+16 7 32.6	Berlin, A.G.C. 1276
6	4 30 21.49	+15 57 29.3	Berlin, A.G.C. 1231

Three comparisons of star 2 with Berlin, A.G.C. 2018, on Oct. 19, 1909, give: $\Delta\alpha - 0^m\ 15^s.85$; $\Delta\delta + 6'\ 14''.3$.

Measured $\Delta\alpha$ (Comet — star 2), 1909 Sept. 24, + 272″.31; Sept. 26, + 80″.94; Oct. 17, − 233″.01.

NOTES ON THE APPEARANCE OF THE COMET, ETC.

1909 *Sept.* 17. The magnitude was estimated 15½; the diameter 5″±. Measured diameter 7″.2. There was possibly a faint nucleus of the 15th magnitude, or an indefinite brightening in the middle. It appeared as a "fleck" of light surrounded by a faint nebulosity for a few seconds. A little later it was quite easy to observe and was estimated to be 15th magnitude. Sky good, seeing good.

Sept. 24. Measured diameter of the full extent of the nebulosity = 11″.1. This nebulosity was extremely faint. There was a brighter "fleck" of light in the middle some 2″ diameter — possibly a nucleus. With 700 diameters the comet was quite easy, the brighter part about 15th magnitude. The whole comet would not be fainter than 15½ magnitude. With this power it was quite noticeable, but there was no nucleus, only an indefinite brightening in the middle.

Sept. 26. It was much brighter and seemed to be about 14 or 14½ magnitude at faintest; measured diameter 9″.5; gradually brighter in the middle. The "fleck" of light seemed to have disappeared the comet was more generally condensed and seemed larger. No definite nucleus. No elongation and no definite boundary.

Oct. 17. The comet was fairly bright, about 13th magnitude, some 10″± in diameter, and brighter in the middle. Seeing bad.

Oct. 19. Diameter 15″±. It was bright in the middle to an indefinite "fleck of light." Estimated to be 13th magnitude — sky very thick.

Oct. 26. Nearly full moon. In the first observations the comet was well seen, but faint, on the moon-lit sky. After moon-set the comet was pretty bright in the middle to nearly a nucleus. Sky fairly clear.

Nov. 14. Estimated magnitude 13 — much brighter in the middle to almost a nucleus. Sky very transparent. During moments of steadiness there was apparently a minute point of light in the nebulosity. The comet was round, with no signs of a tail. Measured diameter = 11″.6.

Nov. 28. Comet bright in nearly full moon-lit sky.

Nov. 30. Before moon-rise, though the comet was very low, it could be seen fairly well with the 4-inch finder of the 40-inch telescope. In the large telescope it was about 11^M. There was almost a nucleus. The measured diameter — the extreme extent of the faint nebulosity of the comet — was 41″. The brightest portion was almost 7″ diameter; and what was perhaps an ill-defined nucleus, was something like one or two seconds in diameter.

It may be interesting to see what the various measures and estimates of the diameter of the comet given in this paper represent. The following table contains these values. From the nature of the case they must be discordant, but I think the mean will not be very far out. I do not think the real diameter will greatly exceed this or it would be indicated on long-exposure photographs.

Observed Diameters of Halley's Comet.

		″	Miles	Weight
1909	Sept. 17	7.2	10800	5
	24	11.1	15900	5
	26	9.5	13400	5
	Oct. 17	10.0±	11200	1
	19	15.0±	16400	1
	26	15.0±	15100	1
	Nov. 14	11.6	9200	5
Mean	Oct. 21		12600	23

Which makes its diameter at these observations about one and one-half times that of the Earth. Of course the diameter of the comet, when at its brightest, will vastly exceed this value.

Yerkes Observatory, 1909 *Nov.* 18.

OBSERVATIONS OF LONG-PERIOD VARIABLES,

By MARY W. WHITNEY and CAROLINE E. FURNESS.

The predictions are based upon V.J.S. for 1909.

V Aurigae. Maximum, $8^M.9$, March 14, '09, from seven observations, Jan. 21, $10^M.2$, to April 22, $10^M.2$.

X Aurigae. Maximum, $8^M.4$, April 1, '09, from eleven observations, Jan. 27, $10^M.4$, to May 12, $11^M.6$.

S Bootis. Seven observations in neighborhood of minimum, March 22, '09, $11^M.0$, through $13^M.0$, May 25, to $12^M.4$, June 24, give a minimum of $13^M.0$ on May 25. Seven observations, Sept. 18, $8^M.7$, to Nov. 26, '09, $9^M.3$, place maximum, $8^M.0$, on Oct. 15, '09. Predicted minimum, May 16; predicted maximum, Sept. 25.

R Cancri. Seven observations, Mar. 18, $11^M.2$, to May 29, '09, $9^M.8$, all on upward slope. Predicted minimum, June 11, '09. Magnitude on June 11 indicated by curve to be $9^M.5$.

U Cancri. Seven observations, Feb. 17, to June 11, '09, $9^M.8$, to $<12^M.4$. Predicted maximum, Mar. 31. By curve on this date magnitude was $10^M.5$.

V Cancri. Six observations, Mar. 20, $10^M.7$, to June 11, '09, $8^M.0$, mainly on rising slope. Maximum near predicted date, May 18, or possibly a little later.

R Can. Min. Six observations, Feb. 26, $8^M.2$, to April 23, '09, $9^M.5$, all on downward curve. The slope may indicate a probable agreement with predicted date of maximum, Jan. 18, '09.

U Can. Min. Four comparisons, Mar. 11, $9^M.6$, to April 23, $9^M.0$, give a trend of curve carrying maximum beyond predicted date, Mar. 26, '09. The magnitude was then $9^M.4$.

R Comae. Mar. 22, '09, estimated $11^M.0$; April 16, estimated $13^M.8$; April 23, $13^M.2$. Six observations follow on rapid upward curve to $9^M.2$ on June 21. Too low to follow longer. Maximum probably near prediction.

X Coronae. During summer of '07 not seen in three-inch telescope, $<10^M$. May 27, '08, barely seen in five-inch, $<11^M$. Six observations, April 24, '09, $8^M.7$, to June 19, $11^M.3$, give a continuous downward slope. Magnitude on predicted date of maximum, May 8, $9^M.2$.

R Cygni. Fourteen observations in 1904, mostly on rising slope, place maximum, $7^M.5$, on Dec. 19. Nine observations, July 17, '09, $7^M.7$, to Nov. 5, $8^M.7$, give a maximum $6^M.8$ on Aug. 9.

X Cygni. Four observations about minimum of 1907 give date of minimum $12^M.8$, Oct. 26, quite near prediction.

V Geminorum. Five observations, '07 April 11, $8^M.4$, to May 11, $9^M.6$, indicate a maximum $8^M.3$ on April 19.

U Orionis. A rising curve from Feb. 13, '09, $11^M.2$, to April 17, $8^M.8$, based on seven comparisons. Minimum plainly preceded Feb. 13.

S Serpentis. From eight observations, Aug. 8, '09, $8^M.0$, to Nov, 3, $11^M.4$, I find a probable maximum, $8^M.0$, on Aug. 13. This precedes the predicted maximum by about twenty days. A like difference occurred in 1907, see *A.N.* 4267.

U Serpentis. Maximum $8^M.6$ on Aug. 30, '09, derived from seven observations, July 24, $10^M.1$, to Nov. 6, $11^M.0$. Predicted date Aug. 22.

RU Urs. Maj. On May 25, '08, $<13^M.0$. Eight observations, Mar. 20, '09, $10^M.0$, to July 1, $10^M.0$, give a maximum $8^M.3$ on April 22.

U Urs. Min. Near Maximum, $8^M.0$, Nov. 29, '08. No preceding observations. Twenty comparisons in 1909 from Jan 18, $9^M.3$, to Nov. 18, $9^M.0$, place minimum, $12^M.0$, on April 28, and maximum, $8^M.3$, on Oct. 20, both fairly near prediction.

Vassar College Observatory, 1909 Nov. 29.

EPHEMERIS OF HALLEY'S COMET,

By Rev. GEO. M. SEARLE.

Date Gr. Mean Noon	α	δ	log Δ	Br. Sept. 11 = 1
1909.0	h m s	° ′		
Dec. 21	3 1 25	+13 19.7		
23	2 52 28	13 0.1	0.134	17
25	44 45	12 40.4		
27	36 48	12 20.6	.138	17
29	29 7	12 1.0		
1910.0 31	21 41	11 41.9	.145	18
Jan. 2	14 37	11 23.3		
4	7 50	11 5.2	.154	18
6	2 1 21	10 47.8		
8	1 55 11	10 31.1	.165	18
10	49 21	10 15.3		
12	43 49	10 0.4	.176	18
14	38 35	9 46.4		
16	33 39	9 33.4	.188	18
18	29 0	9 21.3		
20	24 38	9 10.2	.200	19
22	20 31	9 0.0		
24	16 38	8 50.6	.212	19
26	12 59	8 42.1		
28	9 34	8 34.5	0.223	19
30	1 6 21	8 27.6		

The above ephemeris was computed from the Cowell-Crommelin final elements for 1910.0, as follows:

T = 1910 Apr. 19.692 G.M.T.

$\Omega = 57^\circ\ 16'\ 12''$

$\omega = 111\ 42\ 16$

$i = 162\ 12\ 42$

$a = 17.94527$

$e = 0.967281$

The unit of brightness is that which the comet had Sept. 11, 1909. T was obtained from five observations, as follows:

Sept. 13	Apr. 19.668
26	716
Oct. 19	701
26	683
Nov. 14	692
Mean	Apr. 19.692

OBSERVATIONS OF HALLEY'S COMET.

MADE WITH THE 26-INCH EQUATORIAL AT THE U.S. NAVAL OBSERVATORY.

[Communicated by Captain T. E. De Witt Veeder, U. S. Navy, Superintendent.]

1909 Wash. M.T.		*	Comp.	Δα	Δδ	App. α	App. δ	log pΔ		Red. to App. Pl.	
	h m s			m s	′ ″	h m s	° ′ ″			s	″
Oct. 9	15 18 33	1	5 , 3	+1 50.05	−9 9.9	6 14 41.15	+17 0 29.4	n9.317	0.538	+1.87	+5.2
20	13 40 42	2	25 , 5	+2 18.82	−2 27.2	6 6 36.69	+16 56 56.7	n9.463	0.565	+2.24	+5.3
Nov. 19	12 9 31	3	25 , 5	−0 44.56	−1 41.8	5 8 23.65	+16 32 19.4	n9.122	0.531	+3.21	+8.1

Mean Places of Comparison-Stars for the beginning of the Year.

*	α	δ	Authority	*	α	δ	Authority
	h m s	° ′ ″			h m s	° ′ ″	
1	6 12 49.23	+17 9 34.1	A.G. Berlin A, 2051	3	5 9 5.00	+16 34 23.1	A.G. Berlin A, 1433
2	6 4 15.63	+16 59 18.6	A.G. Berlin A, 1941				

The comet was observed on Oct. 9 by M. Frederickson, on Oct. 20 and Nov. 19 by J. B. Eppes.

NOTE ON *DM* 34°4598.

By PAUL S. YENDELL.

This star at R.A. $21^h\,59^m\,27^s.7$, Decl. 34° 13′.0 (1855), is given in the *DM* as $9^M.2$. It is about 26′ south of the variable 162, 1907 *Pegasi*.

On 1909 Nov. 30, while identifying the latter star, I found 4598 not visible with the aperture of $4\frac{1}{4}$ inches; on Dec. 5, with rather better seeing, it was found to be visible, but $< 10^M$.

I have observed it on five evenings since, comparing it with the star *DM* 33°4424, $9^M.4$. I have always found it $< 10^M$, and the best eye estimates have been $< 10^M.5$.

My observations are as follows:

1909 Nov.	30	not seen;	$< 10^M$
Dec.	5.281	*a* 3 *v*	$< 10^M$
	6.395	*a* 3 *v*	"
	8.260	*a* 5 *v*	
	9.337	*a* 5 *v*	
	10.347	*a* 5-6 *v*	$< 10^M.5$
	11.250	*a* a full mag. brighter than *v*.	$< 10^M.5$.

The apparent increase in the interval is probably not real, but caused by getting better acquainted with the stars. It is a common effect with such faint objects, at least in my own practice.

Dorchester, Mass., 1909 *Dec* 12.

ELEMENTS AND EPHEMERIS OF DANIEL'S COMET (1909 *e*).

By HENRY NORRIS RUSSELL.

The following elements of the Comet discovered by DANIEL at this Observatory, Dec. 6.6, Gr. M.T., are derived from observations by Mr. DANIEL, with the 23-inch equatorial of the Halsted Observatory, on December 7, 8 and 9, which have already been distributed telegraphically. Corrections for parallax and aberration have been applied.

The residuals for the middle place, in the sense O – C, are $\delta\lambda \cos\beta = +3''.4$; $\delta\beta = +2''.2$. The computed position is within 0″.3 of the great circle upon which it should theoretically lie.

ELEMENTS.

$$T = 1909 \text{ December } 1.74722$$

$$\left.\begin{array}{rl} \omega = & 5^\circ\ 30'\ 57'' \\ \Omega = & 73\ \ 31\ \ 29 \\ i = & 26\ \ 50\ \ 28 \end{array}\right\} 1909.0$$

$$q = 1.56156$$

$$\log q = 0.194392$$

CONSTANTS FOR THE EQUATOR OF 1910.0.

$$x = [9.95491]\, r \sin (v + 167^\circ\ 11'\ 35'')$$

$$y = [9.94515]\, r \sin (v + \ \ 92\ \ \ 6\ \ 54)$$

$$z = [9.80679]\, r \sin (v + \ \ 42\ \ \ 3\ \ 52)$$

EPHEMERIS FOR GREENWICH MEAN MIDNIGHT.

	Apparent R.A.	Apparent Decl.	Log Δ	Brightness
1908	h m s	° ′ ″		
Dec. 24	6 18 41.5	+47 30 43	9.8106	0.9
28	6 18 43.7	+49 55 41	9.8240	0.8
1909 Jan. 1	6 18 50.3	+52 2 57	9.8393	0.7
5	6 19 10.4	+53 52 16	9.8561	0.7
9	6 19 52.3	+55 24 22	9.8741	0.6
13	6 21 4.0	+56 40 6	9.8929	0.5
17	6 22 52.6	+57 40 30	9.9124	0.5
21	6 25 22.1	+58 27 12	9.9322	0.4

The brightness on December 8 is taken as unity.

University Observatory, Princeton, N.J., 1909 *December* 16.

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ASTRONOMICAL JOURNAL.

FOUNDED BY B. A. GOULD.

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OBSERVATIONS OF THE SATELLITES OF *URANUS*,

MADE WITH THE 40-INCH TELESCOPE OF THE YERKES OBSERVATORY,

BY E. E. BARNARD.

The great southern declination of *Uranus* and its consequent low altitude, even when on the Meridian here, have made any observations of the satellites difficult. At such a low altitude the seeing is almost always poor, or very bad with a large telescope. I have, however, secured a few measures of the four satellites. The two inner ones have been specially difficult.

All the measures refer to the center of the disc of *Uranus*. They consist of position-angles and distances, the wires being reversed between the first and second sets of distances. No correction has been applied for refraction, though its effect must be considerable under the circumstances. The measures were made with magnifying powers of 460 and 700 diameters. The estimated magnitudes cannot have much value on account of the low altitude of the planet. The times are all $6^h\ 0^m$ slow of Greenwich Mean Time.

THE MEASURES OF THE SATELLITES.

Uranus AND *Titania* — July 28, 1907.

*C.S.Time	P.A.	Dist.	Comp.	Remarks
h m s	°	″		
9 10 13	260.30	....	6	13.5 mag.
9 14 50	....	29.93	4	
9 18 18	....	29.76	4	

Titania AND *Ariel* — July 28.

C.S.Time	P.A.	Dist.	Comp.	Remarks
9 28 24	89.89	....	5	*Ariel* 15 mag.
9 33 47	....	17.51	4	
9 37 16	....	17.02	4	

Umbriel = 15 mag. *Oberon* = 13.5 mag.

Uranus AND *Titania* — Aug. 11.

C.S.Time	P.A.	Dist.	Comp.	Remarks
8 50 52	121.33	....	5	Seeing bad.
8 57 16	....	29.82	5	
9 2 3	....	29.92	5	

Titania AND *Oberon* — Aug. 11.

C.S.Time	P.A.	Dist.	Comp.	Remarks
h m s	°	″		
9 7 51	28.82	....	5	
9 12 26	....	29.36	4	
9 16 18	....	28.89	4	

Uranus AND *Titania* — Aug. 13.

C.S.Time	P.A.	Dist.	Comp.	Remarks
9 9 53	202.38	....	5	Seeing excessively bad. Difficult.
9 15 12	....	31.90	4	
9 19 9	....	32.01	4	

Titania AND *Oberon* — Aug. 13.

C.S.Time	P.A.	Dist.	Comp.	Remarks
9 25 59	87.23	....	5	
9 31 30	...	41.45	4	
9 35 38	...	41.25	4	

Uranus AND *Titania* — Sept. 1.

C.S.Time	P.A.	Dist.	Comp.	Remarks
7 35 49	265.62	....	5	
7 40 26	...	29.57	4	
7 43 22	....	29.49	4	

Titania AND *Oberon* — Sept. 1.

C.S.Time	P.A.	Dist.	Comp.	Remarks
7 49 11	336.64	....	5	Difficult in thick sky.
7 53 52	....	20.06	4	
7 57 37	....	20.19	4	

Uranus AND *Oberon* — Sept. 1.

C.S.Time	P.A.	Dist.	Comp.	Remarks
8 14 55	293.83	....	2	
8 22 59	294.13	....	3	
8 25 52	....	38.69	2	Clouds.

Many small stars in field.

Uranus AND *Titania* — Sept. 10.

C.S.Time	P.A.	Dist.	Comp.	Remarks
7 33 37	279.33	....	5	Observations through a break in clouds.
7 38 28	..	28.15	4	
7 42 0	...	28.86	3	

Uranus AND *Titania* — Oct. 4.

C.S.Time	P.A.	Dist.	Comp.	Remarks
6 33 31	189.97	....	6	
6 39 8	....	30.49	4	
6 42 3	...	30.40	4	

---

* Central Standard Time, 6 hours slow of Greenwich.

Titania and *Oberon* — Oct. 4.

C.S.Time	P.A.	Dist.	Comp.	Remarks
h m s	°	″		
6 46 29	47.81	....	5	
6 50 50	....	57.29	4	
6 54 3	....	57.04	4	

Uranus and *Oberon* — Oct. 4.

6 58 21	78.03	....	5	
7 2 4	....	38.55	4	
7 4 41	....	38.70	4	

Titania and *Umbriel* — Oct. 4.

7 10 57	340.59	....	5	Both satellites very faint.
7 14 57	....	28.39	4	
7 18 22	....	26.98	4	

Uranus and *Titania* — Oct. 6.

6 40 11	271.51	....	5	
6 43 29	....	28.05	4	
6 46 4	....	27.92	4	

Uranus and *Oberon* — Oct. 6

6 56 57	134.91	....	5	
7 1 56	....	38.18	5	
7 5 37	....	39.05	5	

Titania and *Oberon* — Oct. 6.

7 12 7	117.63	....	6	Very difficult and faint.
7 16 28	....	62.08	5	Seeing very poor.
7 20 11	....	62.16	5	

Uranus and *Oberon* — Oct. 8.

6 29 50	187.17	....	5	
6 33 59	....	40.36	4	
6 36 50	....	40.62	4	

Uranus and *Titania* — Oct. 8.

6 40 10	356.80	....	5	
6 43 46	....	30.43	4	
6 46 52	....	30.51	5	

Titania and *Umbriel* — Oct. 8.

6 52 46	162.92	....	5	
6 58 27	....	49.58	4	
7 2 19	....	49.53	5	

Oberon and *Ariel* — Oct. 8.

7 8 31	2.20	....	5	
7 14 37	....	22.29	4	
7 18 33	....	21.89	5	

Oberon and *Umbriel* — Oct. 8.

7 24 17	36.85	....	5	
7 28 43	....	29.03	5	
7 32 17	....	29.76	5	

Titania and *Oberon* — Oct. 8.

C.S.Time	P.A.	Dist.	Comp.	Remarks
h m s	°	″		
7 38 51	184.13	....	5	
7 43 21	....	71.47	4	
7 47 9	....	71.86	4	

Uranus and *Titania* — Oct. 13.

6 25 10	200.69	....	5	
6 28 49	....	30.07	4	
6 31 26	....	30.04	4	

Uranus and *Oberon* — Oct. 13.

6 34 23	323.17	....	5	
6 38 36	....	38.55	4	
6 41 42	....	38.77	4	

Titania and *Oberon* — Oct. 13.

6 44 54	348.43	....	5	
6 49 43	....	60.40	4	
6 54 6	....	60.33	6	

Uranus and *Titania* — Nov. 3.

5 46 24	351.77	....	5	
5 50 50	....	28.48	5	
5 53 59	....	28.94	5	

Uranus and *Oberon* — Nov. 3.

5 58 40	163.28	....	6	
6 3 38	....	39.21	5	
6 6 49	....	39.19	5	

Uranus and *Ariel* — July 7, 1908

11 2 17	212.70	....	6	14 mag.
11 10 2	....	13.96	4	
11 16 14	....	13.89	5	

Uranus and *Titania* — July 7.

11 23 59	133.90	....	5	13.0 mag.
11 30 1	....	29.54	4	
11 33 31	....	29.77	4	

Uranus and *Oberon* — July 7.

11 39 12	291.60	....	5	13.0 mag.
11 43 44	....	38.16	4	
11 47 32	....	38.01	4	

Titania and *Umbriel* — July 7.

11 57 6	276.81	....	6	
12 2 21	....	16.56	5	
12 5 43	....	16.67	5	

Titania and *Ariel* — July 7.

12 11 31	289.43	....	8	
12 15 56	....	31.53	4	
12 18 31	....	31.35	4	

Uranus and *Titania* — July 19.

C.S.Time h m s	P.A. °	Dist. ″	Comp.	Remarks
10 18 53	263.05	....	6	Faint in misty sky.
10 23 27	....	28.85	5	
10 27 14	....	28.75	5	

Uranus and *Oberon* — July 19.

C.S.Time	P.A.	Dist.	Comp.	Remarks
10 33 31	246.13	....	7	Faint in misty sky. Bad seeing.
10 39 14	....	39.67	5	
10 44 7	...	39.25	6	

Uranus and *Titania* — July 21.

C.S.Time	P.A.	Dist.	Comp.	Remarks
12 3 25	353.78	....	6	
12 8 6	....	31.59	5	
12 12 3	...	31.21	5	

Uranus and *Oberon* — July 21.

C.S.Time	P.A.	Dist.	Comp.	Remarks
12 16 26	307.92	....	5	
12 20 47	....	38.58	5	
12 24 25	..	38.71	5	

Uranus and *Ariel* — July 27.

C.S.Time	P.A.	Dist.	Comp.	Remarks
9 24 19	274.49	....	6	
9 29 3	..	13.08	4	
9 31 22	..	13.12	4	

Uranus and *Titania* — July 27.

C.S.Time	P.A.	Dist.	Comp.	Remarks
9 38 45	231.16	....	5	12ᴹ (?) star s.f. 5″ or 6″.
9 43 11	...	30.26	5	
9 49 37	.	30.28	5	

Uranus and *Oberon* — July 27.

C.S.Time	P.A.	Dist.	Comp.	Remarks
9 56 52	102.83	....	5	Seeing very bad. Satellite faint.
10 0 51	..	38.30	4	
10 4 7	..	38.21	4	

Titania and Star (?) same mag. as *Titania* — July 27.

C.S.Time	P.A.	Dist.	Comp.	Remarks
10 14 43	77.66	....	7	
10 20 7		22.93	5	
10 23 38	..	22.65	5	

Oberon and *Umbriel* — July 27.

C.S.Time	P.A.	Dist.	Comp.	Remarks
10 34 37	287.65	....	8	*Umbriel* is ½ mag. less than *Oberon*.
10 41 12	....	20.74	5	
10 44 46	...	21.18	5	

Uranus and *Titania* — July 28.

C.S.Time	P.A.	Dist.	Comp.	Remarks
9 24 26	275.71	....	5	Sky very thick.
9 30 19	..	28.37	4	
9 34 47	..	28.37	3	

Uranus and *Oberon* — July 28.

C.S.Time	P.A.	Dist.	Comp.	Remarks
9 43 49	132.38	....	6	Seeing very good but sky thick and satellite faint.
9 50 19	....	39.43	4	
9 53 44	....	39.35	4	

Uranus and *Titania* — Aug. 2.

C.S.Time h m	P.A. °	Dist. ″	Comp.	Remarks
9 37 20	124.94	....	5	
9 42 6	....	29.17	5	
9 46 50	....	28.96	5	

Oberon and *Ariel* — Aug. 2.

C.S.Time	P.A.	Dist.	Comp.	Remarks
10 7 30	61.43	....	6	
10 11 38	....	35.43	5	
10 15 9	....	35.67	5	

Oberon and *Umbriel* — Aug. 2.

C.S.Time	P.A.	Dist.	Comp.	Remarks
10 21 30	88.47	....	6	
10 27 52	....	20.95	4	
10 32 23	....	21.32	4	

Uranus and *Oberon* — Aug. 2.

C.S.Time	P.A.	Dist.	Comp.	Remarks
9 51 39	262.13	....	5	
9 54 55	...	38.62	5	
9 58 3	....	38.42	5	

Oberon and Faint Star (?) — Aug. 2.

C.S.Time	P.A.	Dist.	Comp.	Remarks
10 39 48	119.59	...	5	The star(?) slightly less bright than *Umbriel*.
10 45 0	....	27.92	4	
10 48 30	....	28.43	4	

Uranus and Object (*a*) North — Aug. 4.

C.S.Time	P.A.	Dist.	Comp.	Remarks
9 35 1	304.68	....	5	*a*, which was measured for *Titania* and which was north, must have been a star, as *Titania* was south.
9 38 56	....	31.02	4	
9 41 18	....	30.73	4	

Uranus and *Oberon* — Aug. 4.

C.S.Time	P.A.	Dist.	Comp.	Remarks
9 44 15	321.05	....	5	
9 48 38	....	39.71	5	
9 52 7	....	39.93	5	

a and *Ariel* — Aug. 4.

C.S.Time	P.A.	Dist.	Comp.	Remarks
10 3 10	152.53	....	6	
10 7 12	....	26.10	1	

Uranus and *Titania* — Aug. 16.

C.S.Time	P.A.	Dist.	Comp.	Remarks
10 8 41	345.37	....	6	Clouds prevented earlier observations.
10 11 16	....	31.09	4	
10 14 24	....	31.63	5	

Uranus and *Titania* — Aug. 22.

C.S.Time	P.A.	Dist.	Comp.	Remarks
8 21 31	224.36	....	5	
8 25 12	....	30.95	4	
8 28 6	....	30.51	4	

Uranus and *Oberon* — Aug. 22.

C.S.Time	P.A.	Dist.	Comp.	Remarks
8 33 43	73.86	....	6	Passing hazy clouds.
8 38 44	....	39.08	5	
8 42 51	....	38.91	5	

Uranus and *Ariel* — Aug. 22.

C.S.Time	P.A.	Dist.	Comp.	Remarks
h m s	°	″		
8 50 44	297.21	....	5	Very difficult. Seeing very poor.
8 55 35	....	12.44	4	
8 59 32	....	12.54	6	

Uranus and *Umbriel* — Aug. 22.

9 9 52	190.37	....	5	
9 14 24	...	19.49	5	
9 17 56	....	18.91	5	

Uranus and *Titania* — Sept. 1.

8 7 19	281.42	....	7	Seeing very bad. Satellite blurred and faint.
8 11 47	....	27.98	4	
8 14 30	....	28.23	4	

Uranus and *Oberon* — Sept. 1.

8 22 31	347.44	....	5	Seeing very bad.
8 27 28	....	41.45	4	
8 31 13	....	41.67	4	

Uranus and *Oberon* — Sept. 15.

7 55 38	0.80	....	7	
8 1 42	....	41.64	5	Sky very thick. Seeing excessively bad.

Uranus and *Titania* — Sept. 20.

7 34 3	308.76	....	6	Very faint.
7 42 19	....	30.51	5	Sky too thick to finish.

Uranus and *Titania* — July 20, 1909.

10 29 29	278.59	....	5	14.5 mag.
10 34 14	..	27.14	5	
10 38 23	...	26.71	5	

Uranus and Star(?) 15^M — July 20.

10 48 48	28.98	....	5	Very difficult. Seeing very bad. High wind.
10 55 59	..	48.38	5	
11 1 9	.	48.07	5	

Uranus and *Oberon* — July 20.

11 15 15	321.90	....	5	Seeing excessively bad.
11 19 56	...	39.95	5	14 mag.
11 23 32	..	39.29	5	

Uranus and *Oberon* — Aug. 2.

9 49 9	306.29	....	6	V. faint and difficult.
9 57 35	....	37.39	4	Full moon and bad seeing.
10 1 18	....	37.63	5	

Uranus and *Titania* — Aug. 2.

10 11 23	95.13	....	6	Very faint and uncertain.
10 17 9	....	26.94	4	
10 20 56	....	27.77	6	

Uranus and *Titania* — Aug. 15.

8 33 51	269.36	...	6	Fairly well seen.
8 38 3	....	26.95	4	
8 40 51	...	27.46	4	

Uranus and *Oberon* — Aug. 15.

C.S.Time	P.A.	Dist.	Comp.	Remarks
h m s	°	″		
8 44 20	291.03	....	5	Fairly well seen at first.
8 48 24	....	36.50	4	
8 51 9	....	36.57	4	

Uranus and *Umbriel* — Aug. 15.

8 56 29	332.68	....	5	
9 1 26	....	18.89	4	
9 6 29	....	18.55	6	

Uranus and *Ariel* — Aug. 15.

9 12 5	314.88	....	7	Tho' nearer, *Ariel* is somewhat brighter than *Umbriel*
9 16 29	....	13.04	4	
9 19 16	....	12.08	4	

There seems to be a slight ellipticity vertically of *Uranus*. It is not marked. P. A. of elongation of disc = 163°.

Uranus and *Titania* — Aug. 17.

9 22 50	356.50	...	5	
9 26 30	...	31.78	4	
9 29 9	...	31.93	5	

Uranus and *Oberon* — Aug. 17.

9 32 41	346.92	....	5	Seeing poor
9 35 37	....	41.84	4	
9 37 53	....	41.90	4	

Uranus and *Oberon* — Aug. 22.

8 44 8	118.02	....	6	
8 49 29	....	36.81	5	
8 53 15	....	36.67	5	

Uranus and *Titania* — Aug. 22.

8 57 13	198.35	....	6	Seeing too poor to measure the other satellites.
9 0 50	....	31.38	5	
9 4 10	....	31.38	5	

Uranus and *Oberon* — Aug. 29.

8 23 47	306.85	....	6	Very difficult. Full moon and bad seeing.
8 29 28	....	37.34	5	
8 33 44	....	37.92	5	

Uranus and *Titania* — Aug. 29.

8 40 55	133.63	...	6	Very faint and difficult.
8 45 37	...	29.12	4	
8 48 25	..	28.66	4	

Uranus and 11^M Star North — Aug. 29.

8 52 36	23.90	.	5	
8 55 35	...	30.58	3	
8 57 33	...	30.64	3	

Uranus and *Titania* — Aug. 31.

7 45 36	206.91	..	7	
7 53 19	..	30.72	4	
7 57 0	..	30.81	5	

Uranus and *Oberon* — Aug 31.

8 2 39	357.44	.	7	Very difficult from full moon and bad seeing.
8 7 33	..	42.74	4	
8 11 23	..	42.32	4	

Yerkes Observatory, Williams Bay, Wis., 1909 *Nov.* 17.

OBSERVATIONS OF COMETS,

MADE WITH THE 26-INCH EQUATORIAL AT THE U. S. NAVAL OBSERVATORY.

[Communicated by Captain T. E. DE WITT VEEDER, U. S. N. Superintendent.]

1908–9 Wash. M.T.	*	Comp.	$\Delta\alpha$	$\Delta\delta$	App. α	App. δ	log $p\Delta$		Red. to App. Pl.	
				Comet 1908 c (Moorhouse).						
1908 h m s			m s	′ ″	h m s	° ′ ″			s	″
Sept. 6 13 24 54	1	25 , 5	−2 39.40	+4 13.0	3 6 16.16	+69 11 15.6	*n*9.912	*n*0.477	+3.48	− 8.1*
12 8 29 12	2	6 , 2	−0 47.95	+12 42.3	2 28 32.69	+72 37 36.6	*n*0.180	0.410	+4.71	− 4.9*
15 8 22 50	3	15 , 5	−1 4.87	−2 37.3	1 57 36.52	+74 23 8.6	*n*0.230	0.138	+5.61	− 2.2*
22 8 54 52	4	9 , 2	+10 48.45	+10 34.2	23 59 53.59	+76 31 38.0	*n*0.140	0.538	+6.20	+10.4*
30 13 58 16	5	25 , 5	−4 38.91	+4 41.5	21 20 43.44	+72 12 8.2	0.167	9.639	+2.89	+21.4*
Oct. 15 8 54 6	6	25 , 5	−1 55.57	−0 12.0	19 26 29.27	+49 47 33.4	9.708	*n*8.908	+0.60	+22.1*
16 11 59 12	7	25 , 5	−0 57.41	+0 26.7	19 22 55.51	+47 47 51.1	9.832	*n*0.611	+0.56	+21.7*
18 8 50 32	8	25 , 5	−1 28.35	−4 28.2	19 17 47.41	+44 29 48.3	9.693	9.932	+0.54	+21.0*
20 8 25 30	9	25 , 5	−0 55.06	−4 51.1	19 13 13.49	+41 1 24.7	9.648	0.037	+0.53	+20.0*
Nov. 5 8 31 48	10	25 , 5	−0 29.20	−6 3.2	18 55 6.54	+16 41 1.2	9.649	0.659	+0.56	+12.3‡
12 7 44 48	11	25 , 5	+1 4.25	+2 34.3	18 52 26.56	+ 8 43 4.7	9.622	0.698	+0.57	+ 9.4‡
15 6 19 46	12	25 , 5	+1 48.36	−2 9.9	18 51 45.39	+ 5 47 13.7	9.524	0.699	+0.58	+ 8.2§
17 7 29 38	13	18 , 6	+0 16.81	−0 7.1	18 51 23.19	+ 3 52 39.5	9.622	0.724	+0.59	+ 7.5§
21 7 16 54	14	25 , 5	−1 16.37	−1 11.3	18 50 52.83	+ 0 26 10.7	9.624	0.739	+0.61	+ 6.3§
25 7 2 58	15	10 , 2	+2 8.60	−8 7.0	18 50 34.39	− 2 41 1.3	9.626	0.749	+0.61	+ 5.2§
27 6 43 49	16	25 , 5	+2 11.10	+2 3.6	18 50 28.29	− 4 7 59.5	9.618	0.755	+0.62	+ 4.7§
Dec. 2 6 12 36	17	25 , 5	+1 3.25	+4 15.6	18 50 18.40	− 7 22 3.9	9.609	0.768	+0.64	+ 3.5§
3 6 17 33	18	15 , 3	−0 49.51	+2 53.9	18 50 17.26	− 8 9 5.0	9.619	0.768	+0.66	+ 2.8§
				Comet 1909 a (Borrelly-Daniel).						
1909										
June 18 15 22 47	19	20 , 4	−1 9.59	−1 48.0	1 48 28.12	+33 15 59.6	*n*9.709	0.516	−0.41	− 6.9*
19 15 14 18	20	20 , 4	−2 22.97	−2 49.6	1 51 23.47	+34 37 36.3	*n*9.721	0.516	−0.41	− 7.0*
20 15 3 49	21	30 , 6	+1 14.67	+8 51.6	1 54 22.97	+35 57 14.3	*n*9.734	0.522	−0.38	− 7.2*
25 15 6 38	22	29 , 6	−1 28.61	+0 2.8	2 10 31.72	+42 10 3.1	*n*9.769	0.426	−0.42	− 7.9*
29 15 12 6	23	35 , 7	−0 31.06	−3 56.1	2 24 46.15	+46 34 10.5	*n*9.797	0.324	−0.42	− 8.4*
July 19 14 37 57	24	30 , 6	−0 21.28	−0 52.7	3 52 24.48	+61 47 25.0	*n*9.980	0.223	−0.44	− 8.6*

Observers: * = M. FREDERICKSON; ‡ = J. C. HAMMOND; § = A. HALL.

Mean Places of the Comparison-Stars for the Beginning of the Year.

*	α	δ	Authority		*	α	δ	Authority	
	h m s	° ′ ″				h m s	° ′ ″		
1	3 8 52.08	+69 7 10.7	Christiania, A.G.	559	13	18 51 5.79	+ 3 52 39.1	Albany, A.G.	6422
2	2 29 15.93	72 24 59.2	Newe's Fund. Cat.	157	14	18 52 8.59	+ 0 27 15.7	Nicolajew, A.G.	4732
3	1 58 35.78	74 25 48.1	Dorpat Zones	+74°.95	15	18 48 25.18	− 2 32 59.5	Strassburg, A.G.	6360
4	23 48 58.94	76 20 53.4	Kasan, A.G.	4238	16	18 48 16.57	− 4 10 7.8	" "	6355
5	21 25 19.46	72 7 5.3	Dorpat Z.	+71°.1068	17	18 49 14.51	− 7 26 23.0	Vienna, A.G.	6428
6	19 28 24.24	49 47 23.3	Bonn, A.G.	13092	18	18 51 6.11	− 8 12 1.7	" "	6455
7	19 23 52.36	47 47 2.7	" "	12988	19	1 49 38.12	+33 17 54.5	Leiden, A.G.	707
8	19 19 15.22	44 33 55.5	" "	12904	20	1 53 46.85	34 40 32.9	" "	744
9	19 14 8.02	41 5 55.8	" "	12801	21	1 53 8.68	35 48 29.9	Lund, A.G.	905
10	18 55 35.18	16 46 52.1	Berlin A. A.G.	7138	22	2 12 0.75	42 10 8.2	Bonn, A.G.	1952
11	18 51 21.74	8 40 21.0	Leipsic II. A.G.	8912	23	2 25 17.63	46 38 15.0	" "	2118
12	18 49 56.45	5 49 15.4	" "	8891	24	3 52 46.20	61 48 26.3	Hels.-Gotha, A.G.	3297

OBSERVATIONS OF VARIABLE STARS, — No. 12,

BY WM. E. SPERRA.

1981. *S Camelopardalis.*

Seventy-three observations of this star forming a two years unbroken series, from 1907 May 1 to 1909 April 15, yield a very interesting light-curve. At first observation star was at $9^{M}.2$ on rise, a stationary phase followed at $8^{M}.9$, and lasted for five weeks, with 1907 June 10 as middle of crest. About the last of June the rise became more rapid until the maximum was reached 1907 Sept. 2, at $8^{M}.1$. The decline then set in and was steady until the minimum, 1908 Jan. 5, at $9^M.9$. A rapid rise followed until $8^M.7$ was reached about March 15, then slowed off to a stationary phase, which nearly amounted to a secondary crest about April 6, at $8^M.6$, and lasted until the first week in June. A steady rise to maximum at $8^M.1$, 1908 July 19. The decline was then steady until minimum light, at $10^M.5$, was reached 1908 Dec. 20. This was followed by a steady rise to $8^M.9$ 1909 April 15, the last observation of the series.

5768. *RR Herculis.*

Twenty-nine observations of this star, commencing when at $8^M.6$, 1907 May 9, and ending 1907 Oct. 8. From first date star rose to maximum, 1907 May 19, at $8^M.4$ then declining to minimum 1907 July 3, at $9^M.1$, then rising more slowly to maximum 1907 Sept. 19, at $8^M.3$.

7085. *RT Cygni.*

This is another star which has been under continuous observation, and what follows continues the series of *A.J.* 601. Seventy-three observations, 1907 Aug. 4 to 1909 Feb. 25, result as follows:

A minimum for 1907 Oct. 3, at $11^M.4$, based on nineteen observations, Aug. 4 – Nov. 23. For nearly six weeks, about equally divided before and after minimum date, the star was below $11^M.2$.

A maximum for 1907 Dec. 18, at $7^M.6$, from thirteen observations, Nov. 23 – 1908 Feb. 23. Unlike the maximum in *A.J.* 601, the rise was steady and rapid, with an abrupt flat crest for three weeks, then a steady, rapid decline.

A minimum 1908 March 29, at $11^M.5$, from nine observations, Jan. 30 to May 17. The stay at minimum was brief, about two weeks.

A maximum 1908 June 28, at $6^M.9$, resulting from twenty-six observations — May 17 to Aug. 13. The rise was rapid until June 4, when $7^M.5$ was reached; it then required two more weeks to reach maximum light, then stationary for a fortnight followed by a rapid decline.

A minimum 1908 Oct. 3, at $11^M.5$, from twelve observations, resembling the preceding March minimum.

A maximum 1908 Dec. 30, at $7^M.0$, from nine observations, Nov. 28 to 1909 Feb. 25, very similar to the preceding June maximum.

7106. *S Vulpeculae.*

Fourteen observations of this star, from 1907 July 18 to 1907 Oct. 6, give a minimum 1907 July 28, at $9^M.7$, and a maximum 1907 Aug. 25, at $8^M.7$. At first observation star was $9^M.5$, and at the last $9^M.6$.

7434. *X Cygni.*

Seventy-five observations, 1907 June 2 to 1908 Jan. 24, yield results for this star as follows:

Minimum	1907	June	13.1	Good
Maximum			16.5	Very good
Maximum		July	4.	Low and flat
Minimum			13.3	Very good
Maximum			21.4	Somewhat uncertain
Minimum			30.0	Good
Maximum		Aug.	4.3	Good
Minimum			15.6	Very good
Maximum			22.0	Somewhat uncertain
Minimum			30.0	Somewhat uncertain
Maximum		Sept.	7.5	Somewhat uncertain
Minimum			16.5	Good
Maximum			24.0	Uncertain
Minimum		Oct.	3.3	Good
Maximum	1908	Jan.	16.5	Somewhat uncertain

7792. *SS Cygni.*

These results are in continuation of my watch of this star, the last being given in *A.J.* 602. The series was badly broken into for reasons given there, but what follows is continuous. Time is G.M.T.

			M				M
1907	May	12.68	11.02 >	1907	May	18.71	8.34
		16.69	8.25			30.68	11.02 >
		17.68	8.32				

1907 June 6 – 15, four normal observations.

			M				M
1907	June	17.66	9.34	1907	July	1.64	9.16
		.71	8.95			2.67	10.02
		18.66	8.38			3.65	10.45
		27.63	8.36			6.65	11.08
		29.62	8.51			12.66	11.17
		30.66	8.99				

1907 July 13 to Aug. 4, eleven normal ($11^M.5$) observations.

			M				M
1907	Aug.	6.60	11.02	1907	Aug.	13.59	9.61
		7.60	11.02 >			14.61	8.97
		8.61	11.20			16.62	8.43
		9.61	11.02?			17.63	8.63
		11.58	10.38			18.58	8.74
		.65	10.40			19.57	9.09
		.89	10.40			21.63	10.04
		12.59	10.04			25.61	11.17
		.90	9.57				

1907 Aug. 30 to Oct. 18, twenty-one normal dates.

			M				M
1907	Oct.	30.57	8.73	1907	Nov.	4.69	10.73

1907 Nov. 14 to Dec. 3, seven normal dates.

			M				M
1907	Dec.	5.49	11.13	1907	Dec.	8.49	9.42
		6.51	10.48			19.49	10.60 >
		7.50	9.95				

Cleveland, Ohio, 1909 *Dec.* 7.

OBSERVATIONS OF HALLEY'S COMET.

By OLIVER J. LEE.

The following positions of Halley's Comet have been derived from plates taken with the two-foot reflector of the Yerkes Observatory:

1909 G. M.T.	Δα	Δδ	App. α	App. δ	Red. to App. Pl.		log pΔ		⁎
h m	m s	′ ″	h m s	° ′ ″	s	″			
Sept. 15 21 0	+0 47.5	−16 36	6 18 50.8	+17 9 50	+1.08	+5.2	*n*9.557	0.656	a
	−0 59.3	+ 7 5	50.8	51	1.07	5.3			b
16 20 45	+0 53.1	−17 4	6 18 56.5	17 9 23	1.10	5.2	*n*9.572	0.660	a
	−0 53.7	+ 6 37	56.4	22	1.10	5.3			b
17 20 10	+0 57.1	−17 26	6 19 0.4	17 9 1	1.12	5.2	*n*9.607	0.681	a
	−0 49.7	+ 6 14	0.5	0	1.13	5.2			b
24 20 27	+0 53.9	−20 17	6 18 57.5	17 6 10	1.36	5.1	*n*9.552	0.652	a
	−0 52.9	+ 3 24	57.5	10	1.35	5.2			b
25 20 29	+0 48.1	−20 43	6 18 51.9	17 5 44	1.48	5.1	*n*9.545	0.649	a
	−0 58.6	+ 2 59	51.8	45	1.38	5.2			b
26 21 17	+0 40.8	−21 7	6 18 44.6	17 5 20	1.60	5.2	*n*9.440	0.618	a
	−1 6.1	+ 2 33	44.3	19	1.42	5.2			b
Oct. 8 18 57	−0 40.0	+32 30	6 15 12.7	17 0 48	1.80	5.3	*n*9.593	0.673	c
	+2 21.8	− 8 50	12.9	49	1.83	5.2			d
	+2 16.6	+12 45	12.8	49	1.82	5.4			e
Oct. 13 18 50	−3 31.3	+30 47	6 12 21.5	16 59 5	1.95	5.3	*n*9.575	0.664	c
	−0 29.6	−10 34	21.7	5	1.98	5.2			d
	−0 34.7	+11 2	21.7	6	1.97	5.3			e
Oct. 13 19 50	−0 31.7	−10 33	6 12 19.6	16 59 7	1.98	5.2	*n*9.475	0.627	d
	−0 36.8	+11 3	19.5	7	1.98	5.3			e
14 20 50	+0 27.6	−14 2	6 11 36.2	16 58 48	2.02	5.2	*n*9.286	0.596	g
15 20 2	+1 9.9	+11 56	6 10 53.7	16 58 29	2.05	5.3	*n*9.422	0.616	f
	−1 15.0	−14 23	53.6	27	2.05	5.0			g
16 21 10	+0 21.1	+11 39	6 10 4.9	16 58 11	2.08	5.3	*n*9.139	0.587	f
	−1 3.8	−14 38	4.9	13	2.08	5.1			g
18 19 10	−1 16.1	+10 58	6 8 27.7	16 57 31	2.14	5.2	*n*9.511	0.638	f
	+0 42.1	− 6 45	27.8	32	2.16	5.2			h
19 18 57	−0 11.9	− 7 4	6 7 33.8	16 57 13	2.19	5.2	*n*9.520	0.641	h
	+2 0.9	+ 5 10	33.8	11	2.20	5.3			i
25 22 2	−0 26.9	+ 4 51	6 0 46.4	16 55 14	2.40	5.6	8.709	0.579	m
26 22 35	−0 3.8	+14 58	5 59 33.7	16 54 59	2.44	5.7	9.102	0.586	j
	+0 59.6	−12 51	34.1	55 3	2.43	5.6			k
26 22 52	−0 4.8	+14 58	5 59 32.6	16 54 59	2.44	5.7	9.205	0.591	j
	+0 58.6	−12 51	33.0	+ 55 3	+2.43	+5.6			k

Mean Places for 1909.0 of Comparison-Stars.

⁎	α	δ	Authority	⁎	α	δ	Authority
	h m s	° ′ ″			h m s	° ′ ″	
a	6 18 2.26	+17 26 21.7	A.G. Berlin A, 2111	g	6 11 6.58	17 12 45.4	A.G. Berlin A, 2038
b	6 19 49.05	17 2 40.3	" " 2132	h	6 7 43.55	17 4 12.4	" " 1989
c	6 15 50.90	16 28 12.4	" " 2087	i	6 5 30.54	16 51 56.0	" " 1960
d	6 12 49.25	17 9 34.1	" " 2051	j	5 59 34.99	16 39 54.8	" " 1886
e	6 12 54.38	16 47 58.3	" " 2052	k	5 58 32.04	17 7 48.5	" " 1875
f	6 9 41.70	16 46 27.3	" " 2019	m	6 1 15.69	16 50 17.4	" " 1905

Yerkes Observatory, 1909 *Dec.* 8.

OBSERVATIONS OF *JUPITER'S* SIXTH SATELLITE,

MADE WITH THE 26-INCH EQUATORIAL AT THE U.S. NAVAL OBSERVATORY,

BY MATT FREDERICKSON.

[Communicated by Captain T. E. DE WITT VEEDER, U.S.N. Superintendent.]

1909 Wash. M.T.	*	Comp.	$\Delta\alpha$	$\Delta\delta$	App. α	App. δ	log $p\Delta$		Red. to App. Pl.	
h m s			m s	′ ″	h m s	° ′ ″			s	″
Apr. 9 10 49 9	1	19 , 4	+2 33.05	−7 8.4	10 27 5.18	+10 52 21.2	9.264	0.624	+0.67	−2.6
10 10 31 50	2	20 , 4	−2 28.77	+0 52.3	10 26 47.09	+10 53 18.4	9.202	0.621	+0.68	−2.7
11 9 42 55	1	30 , 6	+1 58.14	−5 14.2	10 26 30.26	+10 54 15.4	8.851	0.615	+0.66	−2.6
16 9 42 30	1	12 , 5	+0 42.83	−1 30.4	10 25 14.92	+10 57 59.5	9.049	0.616	+0.63	−2.3
22 10 10 41	1	18 , 6	−0 20.81	+0 45.1	10 24 11.20	+11 0 15.4	9.327	0.627	+0.55	−1.9
23 9 26 2	1	18 , 6	−0 28.18	+0 53.5	10 24 3.82	+11 0 23.8	9.133	0.618	+0.54	−1.9

Mean Places of the Comparison-Stars for the Beginning of the Year.

*	α	δ	Authority	*	α	δ	Authority
	h m s	° ′ ″			h m s	° ′ ″	
1	10 24 31.46	+10 59 32.2	Leipsic I, A.G. 4040	2	10 29 15.18	+10 52 28.8	Palisa and Bidschof 372*

* Mean of four observations, one of which seems to be out 5″ in declination.

ELEMENTS AND FINDING EPHEMERIS OF TAUNTON No. 84 (*METCALF*),

BY ELEANOR A. LAMSON.

[Communicated by Captain T. E. DE WITT VEEDER, U.S.N., Superintendent Naval Observatory.]

From observations made by J. C. HAMMOND at Washington on October 26, November 12 and November 27, 1908, the following elements have been computed.

ELEMENTS.

Epoch 1908 Nov. 27.5 G.M.T.

$$
\begin{aligned}
M &= 29^\circ\ 39'\ 32''.6 \\
\omega &= 338\ 41\ 15.2 \\
\Omega &= 29\ 59\ 17.8 \\
i &= 1\ 57\ 22.7
\end{aligned}
\left.\vphantom{\begin{aligned}a\\a\\a\\a\end{aligned}}\right\}\ 1910.0
$$

$$
\begin{aligned}
q &= 6\ 46\ 42.8 \\
\mu &= 563''.846 \\
\log a &= 0.532564
\end{aligned}
$$

The observations made at Washington and published in the *Astronomical Journal*, No. 605, give the following corrections to an ephemeris computed from the elements.

1908	O − C α	O − C δ
	s	″
Oct. 26	−0.09	−0.9
Nov. 12	−0.09	−0.7
15	+0.14	−0.5
18	+0.54	+2.1
22	+0.18	−3.0
27	−0.16	−0.3

HELIOCENTRIC COORDINATES 1910.0

$$
\begin{aligned}
x &= r\,[9.999936]\sin(v + 98^\circ\ 39'\ 40''.9) \\
y &= r\,[9.956774]\sin(v + 9\ \ 7\ 12.7) \\
z &= r\,[9.628593]\sin(v + 6\ 34\ 46.6)
\end{aligned}
$$

EPHEMERIS FOR GREENWICH MEAN MIDNIGHT.

1910	App. α	App. δ	log Δ
	h m s	° ′ ″	
Jan. 1.5	8 9 12.59	+22 52 28.0	0.402569
5.5	8 6 12.74	23 2 34.4	0.400392
9.5	8 3 3.93	23 12 34.9	0.399029
13.5	7 59 48.95	23 22 19.5	0.398510
17.5	7 56 31.00	23 31 35.2	0.398855
21.5	7 53 13.53	23 40 15.1	0.400049
25.5	7 49 59.63	23 48 10.3	0.402086
29.5	7 46 52.09	23 55 15.3	0.404940
Feb. 2.5	7 43 53.75	24 1 26.0	0.408566
6.5	7 41 7.20	+24 6 39.4	0.412931

Opposition 1910 January 17.
Magnitude 1910 January 1.5, is 12.0.

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ON A METHOD OF OBTAINING THE TIME OF PERIHELION IN ANY ORBIT OF WHICH THE OTHER ELEMENTS ARE KNOWN.

By GEORGE M. SEARLE.

I have found this method very convenient in the case of Halley's Comet, and it may be of use in other cases, as T is probably the most uncertain of all the elements, when they have been carried over by perturbations from one apparition to the next.

All that is needed for it is one observation of right-ascension, made after the reappearance.

We have of course the regular equatorial coordinate-equations for x and y, which may be written

$$x = b\,r \sin (v + B)$$
$$y = c\,r \sin (v + C)$$

We have then, denoting by ρ the curtate distance on the equator of the comet or planet from the earth, by α its geocentric right-ascension, by A the geocentric right-ascension of the sun, and by R_0 the earth's radius vector, projected on the equator,

$$\rho \cos \alpha = b\,r \sin (v + B) + R_0 \cos A$$
$$\rho \sin \alpha = c\,r \sin (v + C) + R_0 \sin A$$

$$(b\,r \sin (v + B) + R_0 \cos A) \sin \alpha$$
$$= (c\,r \sin (v + C) + R_0 \sin A) \cos \alpha$$

Developing $\sin (v + B)$ and $\sin (v + C)$, and making

$$b \cos B = m \cos M \qquad b \sin B = n \cos N$$
$$c \cos C = m \sin M \qquad c \sin C = n \sin N$$

this becomes

$$m \sin (\alpha - M)\, r \sin v + n \sin (\alpha - N) \,.\, r \cos v$$
$$= R_0 \sin (A - \alpha)$$

Multiplying the first member by $\frac{1}{mr}$, the second by its equal, $\frac{1 + e \cos v}{mp}$, this equation becomes

$$\sin (\alpha - M) \sin v + \frac{n}{m} \sin (\alpha - N) \cos v$$
$$= \left[\frac{1}{mp} + \frac{e}{mp} \cos v\right] R_0 \sin (A - \alpha)$$

Then, making

$$k \sin K = \frac{n}{m} \sin (\alpha - N) - \frac{e}{mp} R_0 \sin (A - \alpha)$$
$$k \cos K = \sin (\alpha - M)$$

the equation becomes

$$k \sin (v + K) = \frac{1}{mp} \,.\, R_0 \sin (A - \alpha)$$

The practical computation is, then, to obtain, once for all, from the known elements of the orbit, m, n, M, and N; and the quantities $\frac{n}{m}$, $\frac{e}{mp}$, and $\frac{1}{mp}$; these last three, with M and N, may be considered as representing the five known elements.

Then, having given an observation, α, take out A and R for its time, from the Almanac, and compute k and K by the formulas just given. Having then obtained v by the formula for $k \sin (v + K)$, we easily get E (the eccentric anomaly), M (the mean anomaly) and T by the usual formulas.

There will be two values of v, corresponding to the two places where the plane of α (perpendicular to the equator) cuts the curve of the orbit; but of course the right one is easily recognized.

Instead of the above procedure, we can put in the equation

$$m \sin (\alpha - M)\, r \sin v, \text{ etc.}$$

$$r \sin v = a \cos \varphi \sin E$$
$$r \cos v = a (\cos E - e)$$

This gives (a being the semi-axis major)

$$m\, a \cos \varphi \sin (\alpha - M) \sin E + n\, a \sin (\alpha - N) \cos E$$
$$= R_0 \sin (A - \alpha) + n\, a \sin (\alpha - N)\, e$$

$$\frac{m}{n} \cos \varphi \sin (\alpha - M) \sin E + \sin (\alpha - N) \cos E$$

$$= \frac{1}{na} R_0 \sin (A - \alpha) + \sin (\alpha - N)\, e$$

Making

$$h \cos H = \frac{m}{n} \cos \varphi \sin (\alpha - M)$$

$$h \sin H = \sin (\alpha - N)$$

this becomes

$$h \sin (E + H) = \frac{1}{na} R_0 \sin (A - \alpha) + e\, h \sin H$$

This equation gives the eccentric anomaly at once, instead of the true anomaly, given in the previous form; but in very eccentric orbits it may be more accurate to obtain the true anomaly first, and the eccentric from it. The equations can of course be got from those of the coordinates in terms of E.

We may use λ, the geocentric longitude of the comet or planet, R, the unprojected radius vector, L, the longitude of the sun, and the coordinate formulas referred to the ecliptic, instead of the quantities given above.

The right-ascension (or longitude) of the object should of course be reduced to the epoch for which the coordinate equations are calculated, usually that of the beginning of the year; and the value of A or L taken for the same.

OCCULTATIONS OBSERVED DURING THE LUNAR ECLIPSE OF 1909 NOVEMBER 26.

By ERIC DOOLITTLE.

No.	Star		Local Sidereal Time	Washington Mean Time	Mag.
			h m s	h m s	
1	+20°713	D	7 20 31.2	14 50 59.5	9.5
2	+20°715	D	7 46 18.5	15 16 42.5	9.5
3	Anon (*a*)	D	7 47 51.2	15 18 15.0	11.5
4	Anon (*b*)	D	7 51 55.0	15 22 18.1	12.2
5	+20°716	D	7 56 58.8	15 27 21.0	9.0
6	Anon (*c*)	D	7 59 35.8	15 29 57.6	12.5
7	Anon (*d*)	D	8 4 27.2	15 34 48.2	11.5
8	+20°715	R	8 25 36.8	15 55 54.4	9.5
9	Anon (*d*)	R	8 34 5.6	16 4 21.8	11.5
10	+20°716	R	8 44 26.2	16 14 10.7	9.0
11	+20°719	D	8 58 18.9	16 28 30.9	9.5
12	+20°720	D	9 11 14.0	16 41 24.1	8.1

NOTES.

The re-appearance of (1) coincided so nearly with the disappearance of (2) that both could not be observed: similiarly the disappearance of DM +20°718 was almost simultaneous with re-appearance (10). The star DM +19°680 almost touched the S edge of the Moon, but was not occulted. The re-appearances of (7), (11), and (12) were watched for, but by this time the limb was so bright that the stars were wholly invisible for several minutes after emergence.

The positions of the faint stars were measured as follows:

	°	″	
DM +20°715 and Anon (*a*)	291.6	219.8	Two measures.
DM +20°716 and Anon (*b*)	163.7	251.2	Two measures.
DM +20°716 and Anon (*c*)	98.2	129.9	Two measures.
DM +20°716 and Anon (*d*)	333.2	221.8	Two measures.

The Flower Observatory, 1909 *Dec.* 26.

NOTE ON *DM* 34°4600.

R.A. $22^h\,0^m\,9^s.2$; Decl. +34° 44′.8 (1855),

By PAUL S. YENDELL.

This star has been used as a comparison-star for 162, 1907 *Pegasi* on six evenings since 1909 Nov. 29.

As early as December 10, a comparison of the lights indicated for it in several evenings' observations of 162 seemed to indicate that the star was variable in a short period, with a range from $8^M.9$ to $9^M.6$. Observations on two later evenings strongly confirm this impression, and little doubt is left in my mind that the star is variable to the extent of seven or eight-tenths of a magnitude, in a period nearly commensurable with six days.

Its *DM* magnitude is 9.2.

Dorchester, Mass., 1909 *December* 15

OCCULTATIONS OF STARS BY THE MOON,

OBSERVED WITH THE 26-INCH AND THE 12-INCH EQUATORIALS AT THE U.S. NAVAL OBSERVATORY,

Communicated by Captain T. E. De Witt Veeder, U. S N., Superintendent.

Date		Object	Phen.	Wash. Sid. T.	Wash. M.T.	See'g	Instrum't	Pow'r	Obs.	Remarks
1905				h m s	h m s					
July	9	l^2 *Virginis*	D D	17 10 9.3	10 0 39.0	p	12-inch	235	F	
	9	l^2 *Virginis*	R B	18 13 20.2	11 3 39.6	p	12-inch	235	F	Perhaps $0^s.3$ late
	15	B.A.C. 6616	D D	20 17 37.7	12 44 1.2	p	12-inch	235	F	
	24	μ Ceti	D B	22 12 56.0	14 3 37.4	g	12-inch	235	F	
	24	μ Ceti	R D	23 24 49.7	15 15 19.3	g	12-inch	235	F	
	25	f *Tauri*	R D	22 18 41.1	14 5 25.7	. .	12-inch	115	R	Probably $0^s.2$ or $0^s.3$ late
Aug.	13	Mayer 889	D D	0 44 36.6	15 16 15.0	f	12-inch	. .	F	
	17	4 *Ceti*	R D	22 13 48.6	12 30 8.1	g	12-inch	115	R	Perhaps $0^s.3$ late.
	17	5 *Ceti*	R D	22 30 59.6	12 47 16.3	g	12-inch	115	R	Probably $0^s.2$ late.
	19	ν *Piscium*	D B	23 15 41.3	13 23 58.8	b	12-inch	115	F	
	26	f *Geminorum*	D B	1 15 23.–	14 55 50.–	f	12-inch	115	F	Observed eye and ear.
	26	f *Geminorum*	R D	2 12 43.8	15 53 0.9	f	12-inch	115	F	
Sept.	8	Mayer 814	D D	18 51 15.2	7 41 38.0	g	12-inch	115	F	
	12	h′ *Aquarii*	D D	22 4 29.6	10 38 37.1	g	12-inch	335	F	14 hours before full moon.
	12	h′ *Aquarii*	R B	23 17 28.0	11 51 23.5	g	12-inch	335	F	
	14	14 *Ceti*	D B	20 10 43.0	8 37 17.2	p	26-inch	175	F	
	14	14 *Ceti*	R D	21 12 29.3	9 38 53.4	p	26-inch	175	F	
	19	θ^1 *Tauri*	R D	21 53 49.4	10 0 27.3	p	12-inch	115	F	
	19	θ^2 *Tauri*	R D	21 57 56.9	10 4 34.1	p	12-inch	115	F	
	19	81 *Tauri*	D B	22 12 41.4	10 19 16.2	p	12-inch	115	F	Poor obs'n; moon near horizon.
	19	81 *Tauri*	R D	22 23 26.1	10 29 59.1	p	12-inch	115	F	Star reappeared at terminator.
	19	B.A.C. 1406	R D	0 32 25.9	12 38 37.8	p	12-inch	115	F	
	19	α *Tauri*	D B	1 4 28.5	13 10 35.1	p	12-inch	335	F	
	19	α *Tauri*	R D	1 58 16.2	14 4 14.0	p	12-inch	160	F	
Oct.	7	29 *Capricorni*	D D	0 38 45.3	11 34 9.9	f	12-inch	115	F	
Nov.	10	B.A.C. 764	D D	2 33 57.9	11 15 22.7	. .	26-inch	. .	F	
Dec.	4	29 *Piscium*	D D	5 17 58.1	12 24 34.2	b	12-inch	235	R	Possibly $0^s.10$ or $0^s.15$ late.
	10	α *Tauri*	D D	0 52 22.4	7 36 6.5	. .	12-inch	115	R	Not $0^s.10$ late.
	10	α *Tauri*	R B	1 58 17.0	8 41 50.3	. .	12-inch	115	R	Perhaps $0^s.10$ or $0^s.15$ late.
	11	119 *Tauri*	D B	4 12 44.9	10 52 0.3	g	12-inch	235	R	Full moon.
	11	120 *Tauri*	D B	5 6 58.6	11 46 5.1	g	12-inch	235	R	Full moon, obs. uncertain by $0^s.5$

Date	Object	Phen.	Wash. Sid. T.	Wash. M.T.	See'g	Instrum't	Pow'r	Obs.	Remarks
			h m s	h m s					
1906 Feb. 10	*σ Leonis*	D B	11 13 51.0	13 52 6.9	e	12-inch	335	F	
10	*σ Leonis*	R D	12 22 51.3	15 0 55.9	e	12-inch	335	F	
16	29 *Ophiuchi*	D B	15 11 6.9	17 25 8.4	g	12-inch	335	F	
16	29 *Ophiuchi*	R D	16 6 55.6	18 20 48.0	g	12-inch	335	F	Good observation.
Mar. 2	B.A.C. 1406	D D	8 10 36.1	9 30 43.8	..	26-inch	250	F	Hazy.
2	B.A.C. 1406	R B	8 26 53.8	9 46 58.9	..	26-inch	250	F	Hazy.
4	71 *Orionis*	D D	7 7 20.1	8 19 46.4	p	26-inch	375	F	
4	71 *Orionis*	R B	8 35 17.7	9 47 29.6	p	26-inch	375	F	Moon's limb unsteady; perhaps 0s.3 late.
4	B.D. + 19°1269	D D	7 8 10.2	8 20 36.4	p	26-inch	375	F	
Apr. 2	g *Geminorum*	D D	11 55 42.6	11 13 20.4	e	12-inch	335	F	
2	g *Geminorum*	R B	12 54 15.0	12 11 43.2	e	12-inch	335	F	
Apr. 6	*σ Leonis*	D D	10 37 34.5	9 39 41.5	g	12-inch	335	F	
6	*σ Leonis*	R B	11 27 22.5	10 29 21.3	g	12-inch	335	F	
May 2	*α Leonis*	D D	14 20 44.1	11 40 0.9	p	12-inch	235	F	
3	*χ Leonis*	D D	16 20 47.9	13 35 49.1	..	26-inch	250	F	
8	Bradley 1987	D B	12 10 33.0	9 6 35.6	p	12-inch	115	F	Moon near horizon; limb unsteady.
8	*η Librae*	D D	13 7 30.1	10 3 23.4	..	12-inch	335	F	12 hours after full moon.
8	*η Librae*	R D	13 17 27.0	10 13 18.6	..	12-inch	335	F	
11	*ξ¹ Sagittarii*	R D	15 53 23.3	12 37 1.7	f	12-inch	115	F	
June 2	65 *Virginis*	D D	16 46 32.9	12 3 32.6	g	12-inch	115	F	
2	65 *Virginis*	R B	17 24 7.1	12 41 0.7	g	12-inch	115	F	Moon's limb unsteady.
25	7 *Leonis*	D D	15 9 41.3	8 56 31.0	f	12-inch	115	F	
Sept. 1	*ι Aquarii*	D D	18 29 40.0	7 48 35.0	p	12-inch	115	F	Images unsteady.
1	*ι Aquarii*	R B	19 23 51.2	8 42 37.3	p	12-inch	115	F	
Oct. 8	*χ³ Orionis*	R D	0 44 6.0	11 36 31.2	f	12-inch	115	F	
Nov. 21	*ι Capricorni*	D D	0 38 1.1	8 37 27.3	f	12-inch	115	F	
22	45 *Aquarii*	D D	1 45 38.5	9 10 57.7	f	12-inch	115	R	Obs'n good; not over 0s.1 late.
1907 Feb. 22	15 *Geminorum*	D D	8 24 27.4	10 16 57.5	e	12-inch	115	F	
22	16 *Geminorum*	D D	8 22 31.1	10 15 1.5	e	12-inch	115	F	
22	16 *Geminorum*	R B	9 39 41.2	11 32 1.9	e	12-inch	115	F	Emersion poor.
Mar. 22	*ζ Geminorum*	D D	12 1 2.0	12 2 51.3		12-inch	115	F	Sky thick.
24	*δ Cancri*	D D	10 51 37.2	10 15 46.0	g	12-inch	335	F	
24	*δ Cancri*	R B	12 5 16.3	11 59 13.1	g	12-inch	335	F	
Sept. 14	*ξ Ophiuchi*	D D	19 45 9.8	8 13 13.0	e	26-inch	175	F	After the bright star disappeared, a faint
14	(Companion)	D D	19 45 11.3	8 13 17.5	e	26-inch	175	F	companion of about 10.5 mag. became vis.
Oct. 24	Mayer 198	D B	0 53 31.2	10 43 57.6	f	12-inch	115	F	Immersion poor; limb unsteady.
24	Mayer 198	R D	2 1 17.0	11 51 32.3	f	12-inch	115	F	

Date	Object	Phen.	Wash. Sid. T.	Wash. M.T.	See'g	Instrum't	Pow'r	Obs.	Remarks
1907			h m s	h m s					
Oct. 24	107 *Tauri*	D B	2 46 30.2	12 36 38.1	g	12-inch	160	F	
24	107 *Tauri*	R D	4 2 59.0	13 52 54.4	g	12-inch	160	F	
Nov. 16	Lalande 2632	D D	4 2 14.9	12 21 44.5	g	26-inch	375	Hd	Double star.
16	(Companion)	D D	4 2 43.0	12 22 12.5	g	26-inch	375	Hd	
16	Lalande 2632	D D	4 2 15.0	12 21 44.6	g	12-inch	160	F	Star too faint to obs. emersion.
Dec. 11	B.D. – 10°6120	D D	1 45 48.5	8 27 22.7	. .	12-inch	. . .	Fk	
1908									
Jan. 18	*η Cancri*	D B	4 49 20.5	9 0 59.9	p	26-inch	250	Hd	Immersion uncertain by 2 secs.
18	*η Cancri*	R D	6 10 22.2	10 21 48.4	p	26-inch	250	Hd	Emersion well observed.
18	*η Cancri*	D B	4 49 16.7	9 0 56.1	p	12-inch	115	F	Moon's limb unsteady, uncertain.
18	39 *Cancri*	D B	10 9 20.8	14 20 7.8	p	12-inch	115	F	Unsteady.
18	39 *Cancri*	R D	11 32 38.8	15 43 12.2	p	12-inch	115	F	Unsteady.
18	40 *Cancri*	D B	10 14 49.5	14 25 35.6	p	12-inch	115	F	
18	40 *Cancri*	R D	11 37 25.7	15 47 58.3	p	12-inch	115	F	
29	B.A.C. 6088	R D	15 7 37.3	18 34 20.4	.	12-inch	115	F	
Mar. 7	Mayer 121	D D	5 11 14.3	6 10 10.6	f	12-inch	115	F	
7	Mayer 121	R B	6 24 46.8	7 23 31.0	p	26-inch	250	Hd	Perhaps 0s.5 late on account of unsteadiness of Moon's limb.
10	*η Geminorum*	D D	5 38 44.4	6 25 48.5	p	26-inch	250	Hd	
10	*η Geminorum*	R B	6 28 22.2	7 15 18.1	p	26-inch	250	Hd	
10	*η Geminorum*	D D	5 38 44.6	6 25 48.7	f	12-inch	160	F	
10	*η Geminorum*	R B	6 28 23.2	7 15 19.1	f	12-inch	335	F	
Apr. 6	141 *Tauri*	D D	10 53 47.4	9 53 50.4	f	26-inch	250	Hd	
6	141 *Tauri*	R B	11 26 24.2	10 26 21.8	f	26-inch	250	Hd	A trifle late on account of unsteadiness of Moon's limb.
6	141 *Tauri*	D D	10 53 47.5	9 53 50.5	f	12-inch	235	F	
6	141 *Tauri*	R B	11 26 27.0	10 26 24.6	f	12-inch	235	F	Poor.
9	39 *Cancri*	D D	12 46 8.1	11 34 5.0	f	26-inch	250	Hd	
9	39 *Cancri*	R B	13 30 39.5	12 18 29.0	f	26-inch	250	Hd	Emersion probably late on account of faintness of star.
9	39 *Cancri*	D D	12 46 8.1	11 34 5.0	p	12-inch	115	F	
9	40 *Cancri*	D D	12 55 27.5	11 43 22.8	f	26-inch	250	Hd	
9	40 *Cancri*	R B	13 30 0.1	12 17 49.8	f	26-inch	250	Hd	Emersion probably late.
9	40 *Cancri*	D D	12 55 27.6	11 43 22.9	f	12-inch	115	F	
13	*ν Virginis*	D D	8 14 2.2	6 47 0.0	p	26-inch	250	Hd	
13	*ν Virginis*	R B	9 32 11.3	8 4 56.3	p	26-inch	250	Hd	
13	*ν Virginis*	D D	8 14 2.2	6 47 0.0	f	12-inch	115	F	
June 11	o^1 *Librac*	D D	19 6 0.2	13 45 12.5	p	26-inch	375	Hd	
11	o^1 *Librae*	D D	19 6 0.2	13 45 12.5	f	12-inch	. . .	F	
14	Brad. 2276	D B	14 43 17.6	9 11 25.2	p	26-inch	375	Hd	Moon's limb unsteady; time somewhat uncertain
14	Brad. 2276	R B	15 43 44.2	10 11 41.9	p	26-inch	375	Hd	

Date	Object	Phen.	Wash. Sid. T.	Wash. M.T.	See'g	Instrum't	Pow'r	Obs.	Remarks
1908			h m s	h m s					
June 15	χ^3 *Sagittarii*	R D	20 50 16.1	15 13 27.6	p	26-inch	250	Hd	
15	χ^3 *Sagittarii*	R D	20 50 16.4	15 13 28.0	f	12-inch	160	F	
16	Piazzi XX. 146	D B	19 31 19.3	13 50 47.9	f	26-inch	250	Hd	
16	Piazzi XX. 146	R D	20 48 22.0	15 7 38.0	f	26-inch	250	Hd	
July 17	30 *Piscium*	D B	22 6 15.7	14 23 25.7	.	26-inch	250	Hl	
17	30 *Piscium*	R D	22 19 48.8	14 36 56.5	.	26-inch	250	Hl	Late 0^s.2.
17	30 *Piscium*	D B	22 6 16.3	14 23 26.2	f	12-inch	335	F	
17	30 *Piscium*	R D	22 19 48.9	14 36 56.7	f	12-inch	335	F	
Aug. 3	η *Virginis*	D D	18 48 49.5	9 59 41.3	g	12-inch	160	F	
9	χ^3 *Sagittarii*	D D	20 3 7.9	10 50 12.1	. .	26-inch	375	Hl	
9	χ^3 *Sagittarii*	R B	21 8 17.6	11 55 11.2	. .	26-inch	375	Hl	
9	χ^3 *Sagittarii*	D D	20 3 8.1	10 50 12.3	g	12-inch	335	F	
10	Piazzi XX. 146	D D	19 13 18.2	9 56 34.7	.	26-inch	375	Hl	
10	Piazzi XX. 146	R B	20 27 40.1	11 10 44.4	. .	26-inch	375	Hl	
10	Piazzi XX. 146	D D	19 13 18.2	9 56 34.7	. .	12-inch	.	P	
10	Piazzi XX. 146	R B	20 27 39.3	11 10 43.6	. .	12-inch	.	P	
Sept. 6	B.A.C. 6814	D D	17 38 14.8	6 35 37.3	f	26-inch	250	Hd	
6	B.A.C. 6814	R B	18 27 8.1	7 24 22.6	f	26-inch	375	Hd	Prob. late by a fraction of a second.
6	B.A.C. 6814	D D	17 38 14.8	6 35 37.3	p	12-inch	115	F	
Sept. 10	33 *Piscium*	D B	22 22 1.7	11 2 54.1	f	26-inch	375	Hd	Through thin clouds.
10	33 *Piscium*	R D	23 36 13.6	12 16 53.8	f	26-inch	375	Hd	Haze; time somewhat uncertain.
Oct. 14	3 *Geminorum*	D B	2 47 44.2	13 14 12.2	g	12-inch	160	F	
14	3 *Geminorum*	R D	3 40 35.0	14 6 54.4	g	12-inch	160	F	
14	3 *Geminorum*	R D	3 40 35.4	14 6 54.7	.	26-inch	375	Hl	Late. 0^s.5.
Dec. 3	ν *Piscium*	D D	4 24 50.3	11 34 26.9	g	12-inch	115	E	
3	ν *Piscium*	R B	5 0 18.6	12 9 49.4	p	12-inch	115	E	Hazy; probably late.
7	*n Tauri*	D B	3 53 59.2	10 17 57.3	b	26-inch	500	F	Unsteady and diffuse.
7	*n Tauri*	R D	5 9 30.1	12 3 15.8	b	26-inch	500	F	
7	*n Tauri*	D B	3 52 51.8	10 46 53.0	b	12-inch	160	E	Very unsteady.
7	*n Tauri*	R D	5 9 32.2	12 3 17.9	b	12-inch	160	E	
8	3 *Geminorum*	D B	0 18 46.3	7 39 18.7	p	26-inch	250	F	Moon's limb unsteady.
8	3 *Geminorum*	R D	1 1 54.6	7 52 24.9	p	26-inch	250	F	
8	3 *Geminorum*	D B	0 18 51.5	7 39 23.9	b	12-inch	115	E	Unsteady.
8	9 *Geminorum*	D B	1 20 55.2	11 10 52.9		26-inch	375	F	
8	9 *Geminorum*	R D	5 46 56.2	12 36 39.8		26-inch	375	F	
8	9 *Geminorum*	R D	5 46 56.1	12 36 39.7	g	12-inch	115	E	
8	8 *Geminorum*	D B	1 31 9.6	11 21 5.1		26-inch	375	F	
8	8 *Geminorum*	R D	1 56 12.5	11 46 1.1		26-inch	375	F	
9	18 *Geminorum*	D B	1 22 1.3	11 8 3.0	p	26-inch	375	F	Moon's limb unsteady.
9	18 *Geminorum*	R D	1 41 39.2	11 27 37.6	p	26-inch	375	F	

Date	Object	Phen.	Wash. Sid. T.	Wash. M.T.	See'g	Instrum't	Pow'r	Obs.	Remarks
			h m s	h m s					
1908 Dec. 9	48 *Geminorum*	D B	4 22 1.4	11 8 3.1	p	12-inch	160	E	
9	48 *Geminorum*	R D	4 41 39.4	11 27 37.8	p	12-inch	160	E	
1909 Jan. 2	163 B *Tauri*	D D	3 17 55.8	8 29 46.1	f	26-inch	375	F	
2	163 B *Tauri*	R B	4 0 52.0	9 12 35.2	p	26-inch	375	F	Moon's limb unsteady.
27	39 B *Arictis*	R B	7 4 6.4	10 37 1.8	b	12-inch	115	E	Unsteady; probably one or two sec. late.
Feb. 28	8 *Geminorum*	D D	5 29 21.6	6 56 43.4	g	12-inch	196	E	
Mar. 14	63 *Ophiuchi*	D B	15 28 19.7	15 59 0.7	p	12-inch	160	E	
14	63 *Ophiuchi*	R D	16 47 23.6	17 17 51.6	e	12-inch	160	E	
14	63 *Ophiuchi*	R D	16 47 23.8	17 17 51.8	f	26-inch	175	F	
28	ω *Geminorum*	D D	11 24 18.3	11 0 36.6	. .	26-inch	250	F	
28	ω *Geminorum*	R B	12 27 57.1	12 4 5.0	. .	26-inch	375	F	
28	ω *Geminorum*	D D	11 24 18.4	11 0 36.7	g	12-inch	115	E	
28	ω *Geminorum*	R B	12 27 56.7	12 4 4.6	g	12-inch	115	E	
30	γ *Cancri*	D D	8 8 14.5	7 37 13.1	f	26-inch	500	F	
30	γ *Cancri*	R B	8 28 56.7	7 57 51.9	f	26-inch	500	F	
30	γ *Cancri*	D D	8 8 14.3	7 37 12.9	g	12-inch	115	E	
30	γ *Cancri*	R B	8 28 55.5	7 57 50.7	g	12-inch	115	E	
Apr. 24	52 B *Geminorum*	D D	10 32 8.7	8 22 26.0	. .	26-inch	250	F	
24	52 B *Geminorum*	D D	10 32 8.8	8 22 26.1	g	12-inch	335	E	
24	52 B *Geminorum*	R B	11 35 25.5	9 25 32.4	g	12-inch	335	E	
24	Berlin B.A.G.2503	D D	11 34 52.8	9 24 59.8		. .	34	E	Observed with 4″ finder.
May 4	6 B *Librae*	D B	10 21 33.1	7 32 33.1	b	26-inch	250	F	
4	6 B *Librae*	D B	10 21 31.1	7 32 31.1	b	12-inch	160	E	
May 31	4 G *Librae*	D D	15 10 9.2	10 34 12.3	f	26-inch	250	F	Haze.
June 20	γ *Cancri*	D D	14 49 42.8	8 55 11.0	.	26-inch	. . .	F	
July 10	64 *Ceti*	D B	21 13 40.8	13 59 27.8	f	26-inch	250	F	Moon's limb unsteady.
10	64 *Ceti*	R D	22 15 15.5	15 0 52.5	f	26-inch	375	F	
10	64 *Ceti*	R D	22 15 15.8	15 0 52.7	g	12-inch	235	E	
10	ξ^1 *Ceti*	D B	22 9 56.6	14 55 34.4	g	26-inch	375	F	
10	ξ^1 *Ceti*	R D	23 15 21.4	16 0 48.5	g	26-inch	250	F	
10	ξ^1 *Ceti*	D B	22 9 56.7	14 55 34.5	g	12-inch	235	E	
10	ξ^1 *Ceti*	R D	23 15 21.7	16 0 48.8	g	12-inch	235	E	
27	84 B *Scorpii*	D D	18 16 56.6	9 56 22.1	. .	26-inch	250	F	
27	84 B *Scorpii*	R B	19 36 24.3	11 15 36.8	. .	26-inch	250	F	
27	84 B *Scorpii*	D D	18 16 56.6	9 56 22.1	g	12-inch	235	E	
27	51 G *Scorpii*	D D	19 54 25.2	11 33 34.8	. .	26-inch	250	F	
27	51 G *Scorpii*	D D	19 54 25.3	11 33 34.9	p	12-inch	235	E	
Aug. 4	33 *Piscium*	D B	19 12 42.2	10 20 31.3	f	12-inch	115	F	
4	33 *Piscium*	R D	20 12 38.6	11 20 17.8	f	12-inch	115	F	

In third col. DD signifies star disappeared at the dark limb of the Moon; DB, disappeared at the bright limb of the Moon; RD, reappeared at the dark limb of the Moon; RB, reappeared at the bright limb of the Moon.

Observers: R = H. L. Rice; Hl = A. Hall; Hd = J. C. Hammond; F = M. Frederickson; E = J. B. Eppes; Fk = C. W. Frederick; P = G. H. Peters.

ADDITIONAL OBSERVATIONS OF HALLEY'S COMET (See No. 605),

MADE WITH THE 40-INCH REFRACTOR OF THE YERKES OBSERVATORY,

By E. E. BARNARD.

1909 *C.S.T.		Δα	Δδ	Comp.	α Appt.	δ Appt.	Reduced to Appt.		*
	h m s	m s	′ ″		h m s	° ′ ″	s	″	
Dec. 5	9 13 55	−0 2.78	−0 18.8	5 , 8	4 10 20.4	+15 35.3	+3.39	+11.8	7
7	7 23 47	−0 17.30	−0 14.8	7 , 6	4 0 32.34	+15 15 10.7	+3.37	+12.3	8
7	7 38 48	+0 0.50	−0 31.3	6 , 8	4 0 29.64	+15 15 5.6	+3.37	+12.3	9
19	10 11 0	−1 56.37	−0 48.0	22 , 6	3 7 11.23	+13 32 45.4	+3.19	+14.7	10
21	6 23 17	−1 0.82	+1 34.5	22 , 8	2 59 18.77	+13 14 55.3	+3.13	+14.9	11

*Central Standard Time, six hours slow of Greenwich time.

Mean Places of Comparison Stars.

*	α	δ	Authority
	h m s	° ′ ″	
7	4 10 19.8	+15 35.4	12M compared with BD + 15° 604
8	4 0 46.27	+15 15 13.2	Berlin A.G.C. 1083
9	4 0 25.77	+15 15 24.6	BD +15° 578. Compared with Berlin A.G.C. 1083
10	3 9 4.41	+13 33 18.7	Leipzig. A.G.C. 967
11	3 0 16.47	+13 13 5.9	BD +12° 135. Compared with Leipzig A.G.C. 922

Measures of Comparison-Stars.

*	Δα	Comp.	Δδ	Comp.	Compared with
	m s		′ ″		
7	−0 25.79	8	0 0.0		BD 15°604. Exactly the same δ
9	−0 20.50	4	+0 11.4	4	Berlin A.G.C. 1083. Meas. Δα−296″.86
11	−0 40.03	14	−0 13.4	4	Leipzig A.G.C. 922

Measured Δα (Comet-Star) 1909 Dec. 5, −40″.26 ; Dec. 7, −250″.60 at 7h 23m 47s ; Dec. 7, +7″.24 at 7h 38m 48s. The measured values of Δα (Comet-Star) in *A.J.*, No. 605, are partly on star 1.

NOTE.

Dec. 7. Quite easy in 4-inch finder and seems to have a small nucleus. In 40-inch it seemed very much larger. It is 10½ mag., with a small nucleus.

EPHEMERIS OF HALLEY'S COMET.

(Continued from No. 605.)

Gr. M. Noon		α 1910	δ 1910	log Δ	Br. Sept. 11=1
1910		h m s	° ′		
Feb.	3	1 0 25	+8 16.2	0.239	20
	5	0 57 43	8 11.5	0.243	20
	7	0 55 10	8 7.5	0.248	20
	9	0 52 46	8 4.0	0.252	21
	11	0 50 29	8 1.0	0.256	21
	13	0 48 19	7 58.7	0.260	22
	15	0 46 15	7 56.9	0.264	23
	17	0 44 17	+7 55.5	0.267	24
Feb.	19	0 42 24	+7 54.5	0.269	25
	21	0 40 36	7 53.8	0.271	25
	23	0 38 52	7 53.5	0.273	26
	25	0 37 11	7 53.6	0.275	27
	27	0 35 33	7 53.8	0.277	28
Mar.	1	0 33 57	7 54.3	0.278	30
	3	0 32 23	7 54.9	0.278	31
	5	0 30 51	+7 55.8	0.278	33

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On a Method of Obtaining the Time of Perihelion in Any Orbit of Which the Other Elements Are Known, by George M. Searle.
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Occultations of Stars by the Moon, Communicated by T. E. DeWitt Veeder, Superintendent, Naval Observatory.
Additional Observations of Halley's Comet, by E. E. Barnard.
Ephemeris of Halley's Comet, Continued from No. 605, by George M. Searle.

Editor, Lewis Boss, Albany, N. Y.; Associate Editors: Seth C. Chandler and George W. Hill, Directors of the Gould Fund of the National Academy of Sciences. Published by the Dudley Observatory, Albany, N. Y., U. S. A., to which all communications should be addressed. Price, $5.00 the Volume. Press of Thos. P. Nichols & Sons, Lynn, Mass. *Closed Jan. 1, 1910.*

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THE

ASTRONOMICAL JOURNAL.

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No. 608.

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RESULTS OF OBSERVATION WITH THE ZENITH TELESCOPE AND THE WHARTON REFLEX ZENITH TUBE,

AT THE FLOWER OBSERVATORY DURING THE YEARS 1907 AND 1908,

By C. L. DOOLITTLE.

A summary of results of Latitude Observation at this place during the years 1904, 1905 and 1906 may be found in No. 595 of this Journal. This work has since been published in full, forming Part I, Vol. III, Astronomical Series of the publications of the University of Pennsylvania.

In the following pages will be found a further installment of this series. The star-list, methods of observing and reduction are the same throughout. A change in the illumination of the Wharton Instrument was introduced June, 1907, which seems to be a considerable improvement, but the accuracy reached remains very much as before.

All of the observing and much of the computing has been done by myself; the latter, however, has been to a great extent provided for by a very acceptable grant from the Gould Fund, of the National Academy of Sciences.

For further explanation, if such is called for, reference may be had to No. 595, *A. J.*

		Z. Pairs Zen. Tel.				Z. Stars Wharton		
1906	I	No.	II	No.	I	No.	II	No.
			$\varphi = 39° 58'+$					
	″		″		″		″	
Dec. 7	2.32	10	..	..	2.33	8	..	..
11	2.18	10	..	..	2.49	8	..	..
12	2.20	10	..	..	2.43	7	..	..
18	2.38	10	..	..	2.22	8	..	..
19	..	..	..	..	1.90	2	..	..
22	2.41	1	..	..	..	..	..	..
23	2.20	10	..	..	2.37	8	..	..
25	2.23	9	..	..	2.25	8	..	..
1907 Jan. 1	2.27	10	..	..	..	..	..	..
4	2.19	10	..	..	2.52	8	..	..
5	2.16	10	..	..	2.39	8	..	..
10	2.18	10		..	2.50	8	..	..
11	1.92	1		..	2.48	2	..	..

		Z. Pairs Zen. Tel.				Z. Stars Wharton		
1907	I	No.	II	No.	I	No.	II	No.
	″		″		″		″	
Jan. 20	2.10	10	2.27	10	2.29	8	2.43	8
21	2.07	10	..	..	2.28	8	..	..
22	..	..	2.03	10	..	..	2.29	7
23	2.32	10	2.29	8	2.29	8	2.28	8
26	2.20	10	2.38	9	2.45	8	2.41	7
28	2.11	10	..	..	2.49	7	..	..
30	2.06	10	2.19	10	2.43	8	2.50	8
Feb. 5	..	.	..	..	2.22	1	..	..
6	2.20	10	2.14	9	2.36	8	2.31	7
7	2.37	1	..	..	2.58	3	..	..
8	2.10	10	2.13	6	2.46	8	2.22	7
10	2.04	5	.	..	2.44	6	..	..
11	2.16	10	2.07	9	2.34	8	2.35	8
12	2.08	10	2.17	7	2.42	6	2.02	1
13	2.17	10	2.19	7	2.58	8	2.50	2
14	2.16	9	2.15	8	2.66	2	2.41	8
15	2.21	10	..	..	2.34	8	..	..
17	2.18	10	2.25	10	2.50	8	2.58	7
18	2.14	10	2.29	6	2.43	8	2.26	2
20	..	..	2.26	8	..	..	2.30	2
21	2.18	10	2.16	10	2.41	8	2.54	8
22	2.19	10	2.11	10	2.49	8	2.34	7
23	2.28	10	2.12	10	2.54	8	2.58	8
25	2.09	9	2.17	10	2.42	7	2.36	8
27	2.04	10	2.07	10	2.39	8	2.54	8
Mar. 2	..	..	2.04	4	..	..	..	..
4	2.23	9	2.17	3	2.38	8	..	..
6	2.12	10	2.10	10	2.38	8	2.38	8
11	2.18	10	2.06	7	2.22	8	2.32	7
13	2.03	1	..	..	..	..	..	..
15	2.06	10	1.92	8	2.37	8	2.34	8
16	2.05	10	2.07	10	2.20	8	2.33	8
20	2.20	6	1.98	10	2.28	7	2.40	8

	Z Pairs Zen. Tel.				Z Stars Wharton			
1907	I	No.	II	No.	I	No.	II	No.
	″		″		″		″	
Mar. 23		.	2.13	10	..	..	2.40	8
25			1.94	9	..	..	2.32	4
29			2.09	10	..	..	2.30	7
Apr. 2	.		1.90	10	..	..	2.27	8
3	..		1.95	10	..	..	2.28	8
	II		III		II		III	
Apr. 25	1.94	3	..	.	..	..	.	..
27	1.82	4	..	..	2.18	4	.	..
29	1.78	6	..	.	..	..		..
30	1.92	5	..	..	2.12	1		..
May 3	1.83	2	..	..	..	..		..
4	1.88	9	1.95	11	2.38	7	2.32	8
5	2.06	2	..	..	..	..	..	..
11	2.03	10	1.87	11	2.15	8	2.19	9
12	1.76	10	1.99	11	2.21	8	2.33	9
13	1.89	8	1.86	11	2.09	8	1.93	9
14	1.84	10	..	..	1.99	8	2.03	6
17	1.98	9	..	..	2.15	8	..	..
18	1.88	3	..	..	..	..	..	..
20	1.91	10	1.91	11	2.18	8	2.19	9
21	1.95	10	1.88	11	2.13	8	2.11	9
27	1.92	9	2.02	11	2.09	7	2.16	9
28	1.91	10	1.94	11	2.11	5	2.16	7
29	..	..	1.86	11	..	..	2.08	7
30	1.93	8	1.88	11	2.08	8	2.05	9
June 5	1.97	7	1.92	11	2.34	5	2.13	9
6	1.93	8	1.94	11	2.11	6	2.18	9
8	1.99	6	1.96	10	2.32	7	2.25	9
9	1.95	5	2.01	10	2.13	8	2.35	9
15	..	..	1.82	11	..	..	2.30	9
16	..	..	2.01	11	..	..	2.14	9
21	..	..	1.85	9	..	..	2.17	7
	III		IV		III		IV	
July 7	1.86	10	2.00	5	2.10	6	2.20	8
9	1.93	9	1.94	5	2.10	6	2.13	7
10	1.76	5	..	..	2.24	4	..	..
12	1.68	11	1.70	5	2.18	9	2.27	8
13	1.91	8	1.84	7	2.26	5	2.26	8
14	1.84	11	1.88	10	2.21	9	2.28	10
15	..	..	..	..	2.22	1	.	.
16	..	..	1.82	3	.		2.09	10
17	1.84	3	.		2.17	2	.	..
19	1.90	8		.	2.45	5	.	.
20	1.83	4	1.93	7	2.04	6	2.16	9
21	1.95	11	1.92	10	2.30	9	2.17	10
22	1.77	4	..	..	2.28	3	.	..
23	2.14	9	1.89	9	2.21	6	2.05	8
26	1.90	11	1.98	10	2.22	9	2.37	10
27	1.97	8	1.86	10	2.04	9	2.18	10
28	2.19	4	.	.	2.38	6	..	..
29		.	1.97	7		..	2.15	8
30	2.06	11	1.94	9	2.19	9	2.17	10
31	1.90	11	1.90	7	2.21	9	2.35	10
Aug. 1	2.02	11	2.25	5	2.11	8	2.25	6
4	1.74	11	1.90	10	2.19	8	2.10	10
6	1.95	5	..	..	2.12	2	2.12	4

	Z Pairs Zen. Tel.				Z Stars Wharton			
1907	III	No.	IV	No.	III	No.	IV	No.
	″		″		″		″	
Aug. 7	2.03	9	1.88	8	2.20	9	2.30	10
8	1.68	1	..	..	2.43	2	..	.
11	2.08	8	..	..	2.27	7	..	..
12	1.79	10	1.80	8	2.08	8	2.19	10
13	1.76	11	1.79	10	2.18	9	2.12	10
14	1.94	8	1.95	9	2.25	7	2.18	10
15	1.74	9	1.78	10	2.21	8	2.26	10
17	2.13	3	..	..	2.40	4	.	..
18	1.96	4	2.12	10	2.38	2	2.15	10
19	1.94	9	..	..	2.20	8	..	.
22	1.97	10	1.95	10	2.18	8	2.33	7
	IV		I		IV		I	
Sept. 13	2.13	7	..	.	2.31	8		.
14	2.05	10	..	.	2.17	10		..
15	2.00	7	.	.	2.23	5	.	.
16	2.03	10	..	.	2.07	10		..
25	2.02	10	..	.	2.31	9	.	..
26	2.03	10	..	..	2.47	10	.	..
27	1.94	10	..	..	2.32	10	..	..
30	2.26	7	..	..	2.47	9	..	..
Oct. 1	2.08	10	..	..	2.30	10	.	..
5	2.10	9	..	.	2.19	10	..	..
8	2.05	10	..	.	2.30	10	.	.
10	1.94	8	..	..	2.31	10	..	..
12	2.00	9	..	.	2.26	10	..	.
13	2.09	9	..	.	2.27	10	.	..
14	2.07	10	2.07	8	2.17	10	2.14	5
15	1.96	10	2.18	8	2.29	10	2.35	3
16	2.02	10	1.97	10	2.32	10	2.21	6
17	2.10	2	2.10	9	2.40	7	2.34	4
18	2.16	10	1.93	9	2.28	10	2.23	6
19	2.17	10	2.33	1	2.33	5	2.46	1
20	.	..	2.04	7	..	..	2.62	8
21	2.00	10	2.10	10	2.24	10	2.39	7
22	2.16	10	2.04	10	2.42	8	2.34	7
23	2.20	10	2.07	10	2.29	10	2.41	8
24	2.11	10	2.10	10	2.36	8	2.25	8
25	1.95	4	1.83	9	2.26	10	2.11	8
26	2.06	10	1.97	9	2.36	10	2.17	8
29	1.96	10	..	..	2.27	10	..	.
30	2.04	9	2.15	10	2.27	10	2.21	8
31	2.04	10	2.07	9	2.32	10	2.32	7
Nov. 3	2.21	1	.	.	2.30	4		.
4	2.08	8	2.21	10	2.35	10	2.42	8
5	2.16	10	..	.	2.32	10	.	.
7	.	..	2.18	10	.	.	2.31	8
9	2.06	4	.	.	2.37	9		.
11	2.02	9	..	.	2.26	10	2.49	2
13	2.19	10	2.12	10	2.30	10	2.36	8
14	2.20	10	2.18	9	2.22	10	2.38	8
15	2.20	10	2.13	7	2.37	9	2.30	6
16	2.16	9	2.13	7	2.42	8	2.32	7
17	2.32	10	..	.	2.37	10	.	.
19	2.13	9	..	..	2.27	10		..
25	2.14	5	2.32	6	2.43	2	2.40	7
27	2.16	10	..	..	2.31	8		..

	Z Pairs Zen. Tel.				Z Stars Wharton			
1907	IV	No.	I	No.	IV	No.	I	No.
	″		″		″		″	
Nov. 28			2.28	9	..	..	2.24	8
29			2.13	10	..	..	2.14	8
30	2.07	8	..	..	2.27	6	..	..
Dec. 2	2.02	2	2.20	9	2.32	2	2.33	8
	I		II		I		II	
Dec. 6	2.27	6			2.50	7		..
7	..	..	..		2.46	1		..
8	2.34	10	..	..	2.49	7		..
12	2.20	10	..		2.30	7		..
31	2.44	10	..		2.55	8	..	..
1908 Jan. 1	2.28	4	..	..	2.56	7		..
2	2.43	1	..		2.38	3		..
5	2.44	9	..		2.51	8		..
6	2.48	8			2.62	8		..
9	2.37	8	..		2.49	7		
10	2.29	10	..		2.59	8		
15	2.12	1			2.46	1		..
16	2.34	10	..		2.52	8		
17	2.40	8	..	..	2.47	8		
18	2.32	7	..		2.43	8	..	..
19	2.27	10	..	..	2.50	8	..	..
25	2.39	8	2.36	10	2.31	6	2.39	6
27	2.30	10	2.31	7	2.52	8	2.47	8
29	2.36	7	2.26	8	2.61	8	2.78	6
30	2.40	10	2.40	9	2.64	8	2.43	8
Feb. 2	2.42	10	2.44	10	2.53	8	2.52	8
3	2.23	4	..	..	2.57	5	..	..
4	2.39	10	2.30	10	2.40	8	2.30	8
6	2.28	8	..	..	2.54	6	..	..
7	2.31	9	..	..	2.48	8	..	..
8	2.28	10	2.22	10	2.42	8	2.56	8
9	2.33	9	2.46	8	2.47	8	2.47	8
10	2.42	10	2.32	10	2.51	8	2.41	8
11	2.29	10	..		2.48	8	..	..
16	2.36	6	..	..	2.43	6	..	..
17	2.41	6	2.34	8	2.44	5	2.41	8
20	2.39	10	2.38	10	2.59	8	2.49	8
22		..	2.32	8	..	..	2.40	7
23	..	..	2.32	10		..	2.59	8
24	2.41	10	2.46	10	2.42	8	2.38	8
26	2.35	9	2.31	9	2.44	8	2.46	8
27	2.36	10	..	..	2.43	7	..	..
28	2.52	3	2.28	10	2.49	4	2.54	8
29	2.20	10	2.48	10	2.42	8	2.42	7
Mar. 3	2.45	10	2.32	10	2.44	8	2.38	8
4	2.39	10	2.50	10	2.41	8	2.44	8
7	2.33	9	2.23	9	2.37	8	2.38	8
10	2.33	10	2.24	10	2.50	8	2.36	8
12	2.46	10	2.44	8	2.33	7	2.52	7
14	2.35	10	2.37	7	2.29	7	2.41	4
15	2.37	8	2.44	6	2.17	8	2.15	2
16	2.27	9	..	..	2.20	8	..	..
19	2.23	6	..	..	2.35	7	..	..
20	..	..	2.46	10	..	..	2.28	8
21	2.46	8	2.37	10	2.39	5	2.37	8

	Z Pairs Zen. Tel.				Z Stars Wharton			
1908	I	No.	II	No.	I	No.	II	No.
	″		″		″		″	
Mar. 24	..	..	2.34	10	..	..	2.30	8
25	..	..	2.24	10	..	..	2.25	8
27	..	..	2.47	1		..	..	..
Apr. 3	..	..	2.40	7	..		2.32	1
4	..	..	2.27	10	..		2.36	8
6	..	..	2.32	10	..		2.34	8
9	..	..	2.28	10	..		2.61	8
10	..	..	2.31	10	..	..	2.27	8
	II		III		II		III	
May 1	2.16	10	..	..	2.29	8	..	..
2	2.07	8	2.12	10	2.27	8	2.37	8
3	2.17	9	..	..	2.30	6	..	..
10	2.23	10	2.11	11	2.29	8	2.21	8
12	2.15	5	2.22	10	2.10	4	2.44	9
16	2.14	6	..	..	2.37	1	..	..
17	2.20	3	2.35	7	..	..	2.33	5
18	2.23	10	2.31	7	2.19	8	2.32	5
23	2.29	8	..	..	2.20	2	..	..
24	2.31	9	2.19	11	2.22	8	2.15	9
25	2.16	7	..	..	2.25	5	..	..
26	2.33	8	..	..	2.20	6	..	..
27	2.28	9	2.25	11	2.25	7	2.30	6
29	2.80	1	..	..	..	..	..	..
30	2.23	6	2.23	5	2.59	1	2.41	3
31	2.05	10	2.45	1	2.22	7	1.96	1
June 1	2.17	10	2.16	11	2.12	8	2.26	9
2	2.34	8	2.09	6	2.13	6	2.04	6
4	2.21	8	2.25	11	2.15	8	2.14	6
5	2.04	8	..	..	2.38	5	..	..
6	2.23	6	2.25	9	2.10	8	2.17	9
7	2.03	7	2.23	11	2.29	8	2.19	3
8	2.30	4	2.16	9	2.14	8	2.12	9
10	2.15	6	2.17	9	2.11	7	2.01	9
11	2.21	5	2.03	10	2.31	8	2.24	8
12			2.04	4		..	2.01	7
13	..	..	1.92	11		..	2.33	9
14	..		1.99	7	..	..	2.10	5
16		..	2.02	11	..	..	2.07	9
18			1.92	11		..	2.02	9
19			1.92	10		..	2.25	3
20			2.20	8		..	2.14	7
22		..	1.96	11		..	1.99	9
23		..	2.15	11		..	2.12	6
26		..	2.05	5		..	2.48	2
27		..	2.04	11	..	..	2.10	9
29	..	..	1.90	6	..	..	2.01	6
July 1	2.03	11	2.00	6	2.10	9	2.18	9
3	1.82	3	..	..	2.12	3	..	..
5	1.98	11	1.95	10	2.15	7	1.98	8
6	1.87	6	..	..	..	..	..	..
8	2.14	11	1.98	10	2.12	9	2.08	10
10	1.96	11	2.16	10	1.95	9	2.11	10
11	1.96	11	..	..	2.11	8	..	..
13	2.02	10	..	..	2.03	6	2.14	1
15	2.20	5	2.02	10	2.22	4	2.07	10
16	2.12	11	1.97	10	1.94	9	2.07	10
17	1.88	4	..	..	2.26	2	..	..

		Z Pairs Zen. Tel.				Z Stars Wharton			
1908		III	No.	IV	No.	III	No.	IV	No.
		″		″		″		″	
July	18	1.81	3	. .	. .	. .	. .	. .	. .
	19	2.05	10	2.08	8	1.88	9	1.98	10
	20	1.99	10	1.79	7	2.00	9	1.89	7
	27	2.00	9	1.98	9	2.12	1	2.07	5
	28	1.87	5	. .	. .	2.28	5	. .	. .
	29	1.94	10	. .	. .	2.02	7	2.09	2
	30	1.96	11	2.21	7	2.06	9	2.19	8
Aug.	1	1.91	11	2.00	10	1.97	9	1.82	10
	2	1.97	9	. .	. .	1.90	7	. .	. .
	3	1.87	11	1.89	9	1.96	8	1.92	9
	4	1.95	8	. .	. .	2.01	6	. .	. .
	6	1.96	8	. .	. .	1.93	5	. .	. .
	8	. .	. .	. .	. .	2.09	2	. .	. .
	9	. .	. .	1.98	9	. .	. .	1.98	10
	10	1.90	9	1.85	10	2.08	5	1.94	10
	11	. .	. .	2.05	10	. .	. .	2.15	8
	12	1.87	11	1.83	8	1.95	5	2.02	7
	13	2.13	7	. .	. .	1.89	5	. .	. .
	14	2.00	10	2.02	2	1.95	9	1.99	9
	18	1.92	10	1.98	10	2.00	8	1.96	10
	19	1.88	10	1.85	8	2.01	8	1.91	9
	20	1.92	10	1.84	10	2.04	8	2.04	10
	21	1.96	9	. .	. .	1.86	8	. .	. .
	22	1.86	4	1.69	3	1.94	4	1.96	10
		IV		I		IV		I	
Sept.	7	1.92	10	. .	. .	1.93	10	. .	. .
	8	1.94	10	. .	. .	2.24	10	. .	. .
	9	1.89	10	. .	. .	2.11	10	. .	. .
	14	1.86	10	. .	. .	2.04	10	. .	. .
	15	1.84	10	. .	. .	2.13	10	. .	. .
	16	. .	. .	. .	. .	2.04	5	. .	. .
	18	. .	. .	. .	. .	2.20	6	. .	. .
	21	1.90	10	. .	. .	2.08	10	. .	. .
	30	1.89	9	. .	. .	2.06	10	. .	. .
Oct.	2	1.87	10	. .	. .	2.13	10	. .	. .
	3	1.72	10	. .	. .	1.98	10	. .	. .
	4	1.94	10	. .	. .	2.20	10	. .	. .
	5	1.87	10	. .	. .	2.04	10	. .	. .
	6	1.94	10	. .	. .	2.13	10	. .	. .
	11	1.84	9	. .	. .	2.12	9	. .	. .
	12	1.91	10	. .	. .	2.10	10	. .	. .
	13	1.77	9	. .	. .	2.11	10	. .	. .
	15	1.85	10	1.84	8	2.12	9	2.03	4
	16	1.88	10	1.89	10	1.97	10	2.01	5
	17	2.14	8	1.89	10	2.17	10	1.87	6
	18	2.03	10	1.96	9	2.13	10	1.98	6
	20	1.83	9	. .	. .	2.16	10	. .	. .
	25	. .	. .	. .	. .	2.11	2	. .	. .
	26	2.12	5	. .	. .	2.12	9	. .	. .
	27	. .	. .	. .	. .	2.17	3	. .	. .
	30	1.82	7	. .	. .	1.99	10	. .	. .
	31	1.77	10	. .	. .	2.01	9	. .	. .
Nov.	1	1.86	10	1.90	10	2.05	10	2.01	8
	2	1.76	9	1.96	10	2.06	10	2.02	8
	3	2.00	9	1.89	4	2.08	10	1.98	4
	5	. .	. .	1.91	9	. .	. .	2.05	8
1908		IV	No.	I	No.	IV	No.	I	No.
		″		″		″		″	
Nov.	6	1.94	3	. .	. .	2.10	10	. .	. .
	7	. .	. .	. .	. .	1.82	3	. .	. .
	8	. .	. .	1.93	10	. .	. .	2.05	8
	12	1.86	10	1.87	10	1.76	10	1.99	8
	13	1.89	10	1.91	10	1.98	10	1.96	8
	15	1.81	10	2.05	9	1.75	10	2.11	8
	16	1.92	6	1.92	10	1.90	7	1.90	8
	17	1.89	9	. .	. .	2.02	9	. .	. .
	18	. .	. .	. .	. .	1.88	2	. .	. .
	20	1.88	10	1.88	9	1.79	8	1.92	8
	21	2.10	10	2.04	10	2.06	8	2.09	7
	22	2.00	10	. .	. .	1.93	7	. .	. .
	27	2.08	10	2.05	10	1.99	8	1.99	8
	28	. .	. .	1.92	9	. .	. .	1.92	5
	29	. .	. .	. .	. .	2.11	2	. .	. .
	30	2.06	8	. .	. .	1.88	5	. .	. .
Dec.	1	2.03	5	1.86	10	1.86	3	. .	. .
	2	1.84	9	1.89	10	1.90	7	1.96	8
	5	. .	. .	1.95	10	. .		1.99	8
	8	. .	. .	1.98	10	.	.	2.13	7
	10	. .	. .	. .	. .		. .	1.90	1
	12	. .	. .	2.01	9		.	1.97	8
	13	. .	. .	1.95	10		.	2.37	8
	15	. .	. .	2.00	1	.	. .	2.16	2
	18	. .	. .	1.97	10	. .	.	2.02	8
	19	. .	. .	2.07	10	.	.	2.09	8
	20	. .	. .	1.94	10	.	.	2.12	8
	23	. .	. .	1.98	4		.	2.48	3
	27	. .	. .	2.07	7		.	2.04	6

Final Values of the Latitude.

$\varphi = 39° 58' +$

Weighted Mean Date			Z Tel.	No.	Wharton	No.
			″		″	
1906	Dec.	25	2.229	101	2.378	75
1907	Jan.	30	2.190	167	2.371	125
	Feb.	18	2.180	165	2.452	125
	Mar.	8	2.088	147	2.356	117
	Mar.	29	2.003	49	2.310	35
	Apr.	29	1.851	20	. . .	. .
	May	13	1.908	147	2.155	110
	June	2	1.938	139	2.161	131
	June	17	1.898	31	2.207	25
	July	14	1.870	132	2.200	132
		29	1.951	152	2.184	145
	Aug.	15	1.900	147	2.213	139
	Sept.	27	2.044	117	2.283	131
	Oct.	18	2.068	153	2.323	117
		29	2.076	163	2.294	164
	Nov.	20	2.172	159	2.312	147
1907	Dec.	21	2.341	50		
1908	Jan.	1	.		2.500	104
		14	2.346	62	.	.
		31	2.342	167		

Final Values of the Latitude. — (*Continued.*)

$\varphi = 39° 58' +$

Weighted Mean Date	Z Tel.	No.	Wharton	No.
	"		"	
1908 Feb. 2	....	...	2.488	157
21	2.360	149	2.462	124
Mar. 11	2.367	190	2.363	135
Apr. 4	2.284	78	2.356	49
May 16	2.216	159	2.272	121
June 5	2.177	161	2.176	137
20	2.007	106	2.106	81
July 9	2.016	150	2.080	124
29	1.968	164	1.982	123
Aug. 16	1.916	141	1.981	150
Sept. 14	1.894	69	2.095	71
Oct. 7	1.886	78	2.096	89
26	1.908	180	2.044	182
Nov. 21	1.940	204	1.946	164
Dec. 16	1.990	81	2.110	67
		4178		3596

For the purpose of comparison of the results obtained from the two instruments with reference to the evidence given as to the genuineness of the daily fluctuations, the residuals are formed by subtracting the daily means from the final values into which they enter. The agreement or disagreement of the corresponding residuals should throw some light on this question. In those cases where two groups are observed on the same night they are compared separately.

Including everything indiscriminately we have the following result:

	1907	1908	
Both residuals zero	2	0	
One residual zero	19	21	
Like signs	106	122	
Unlike signs	96	106	
	223	249	total 472

Considered in this way the evidence does not appear to be very conclusive. It is however to be remembered the considerable majority of the residuals are small, in many cases much less than their probable error.

Confining our attention to the larger residuals we have the following result. In the tabular statement v and v_1 are the residuals given by the Zenith Telescope and the Wharton Instrument respectively in units of the second decimal place, n the number of determinations.

Both residuals four times the probable error or greater:

	v	n	v_1	n
1907 Sept. 30	−22	7	−19	9
1908 July 30	−22	7	−22	8

Not less than three times the probable error:

	v	n	v_1	n
1906 Dec. 18	−15	10	+16	8
1907 July 28	−23	4	−19	6
Oct. 25	+25	9	+17	8
Dec. 12	+14	10	+20	7
1908 Aug. 11	−15	10	−16	8

Not less than twice the probable error:

	v	n	v_1	n		v	n	v_1	n
1907 Jan. 23	−18	10	+10	8	1908 Jan. 6	−13	8	−12	8
Feb. 13	− 9	10	−12	8	Mar. 3	−10	10	−10	8
July 21	−10	11	−10	9	25	+14	10	+11	8
Aug. 12	+12	10	+14	8	Apr. 9	+10	10	−25	8
13	+11	10	+ 9	10	June 2	+12	6	+12	6
17	−22	3	−18	4	5	+14	8	−18	5
Oct. 16	+ 9	10	+14	6	July 15	−18	5	−14	4
18	+13	9	+12	6	16	−10	11	+14	9
26	+11	9	+11	8	19	−10	10	+11	9
Nov. 4	−13	10	−14	8	Oct. 17	−23	8	− 9	10
					Nov. 15	+13	10	+16	10
					15	−11	9	−13	8
					21	−16	10	−10	8
					21	−10	10	−11	7

For the 1904–05–06 Series the result was as follows:

Both residuals, four times the probable error — none.

Not less than three times the probable error:

Like signs 4; unlike signs 0.

Not less than twice the probable error:

Like signs 59; unlike signs 26.

Whatever cause may be assigned for their occurrence the decided preponderance of like signs in these larger residuals seems to show that actual daily fluctuations of very appreciable magnitude do sometimes take place.

The following values for the constant of aberration result from this series:

	Zenith Telescope		Wharton Instrument	
1907	20.504″	±.0095	20.554″	±.0108
1908	20.507	±.0095	20.541	±.0104

The probable error of a single determination of latitude has been computed in the usual manner from the final values and includes the error of the group adjustment. The result is as follows:

Zenith Telescope		Wharton Instrument	
1907	±0.147″	1907	±0.147″
1908	±0.141	1908	±0.140

These errors are somewhat larger than was anticipated but this is due, in part at least, to the fact that observation was carried on whenever possible, even when conditions were very poor. It was considered very important to obtain results on every possible occasion for the purpose of testing the character of the anomalous fluctuations. With very few exceptions every available night during the two years has been utilized.

An examination of the final results for latitude given by the two instruments shows very marked systematic differences. These are no doubt chargeable to the Wharton Instrument. The method of observing is as follows: Two bisections of the star are made in the first position, the instrument is reversed and two bisections at the same points in reference to the meridian are made in the second position. In one case the apparent motion of the star is upward, in the other downward. Two possible causes of systematic error are suggested — first, a gradual change in the observer's personal habit of bisection, and second, insufficient attention to the inclination of the thread. For the future it is hoped that the first cause may be eliminated by introducing an inverting prism, making the two bisections in each position with the apparent motion in opposite directions, for the second, more frequent determinations will be made of the inclination of the thread.

There seems little reason to fear that comparison of results for short periods will be seriously affected by this cause. Whatever changes may have taken place seem to have been gradual in character. The daily fluctuations are not likely to be materially affected. It is different however, with the general result for an entire year. The value of the constant of aberration in particular given by the Wharton Instrument is probably not entitled to much confidence.

1909 *Dec.* 25.

OBSERVATIONS OF COMET 1909 *e* (DANIEL),

MADE WITH THE 11-INCH EQUATORIAL AT SMITH COLLEGE OBSERVATORY, NORTHAMPTON, MASS.,

By HARRIET W. BIGELOW.

1910 Gr. M.T.	*	Comp.	Δα	Δδ	App. α	App. δ	log pΔ		Red. to App. Pl.	
Dec. 9 16ʰ 12ᵐ 28ˢ	1	12*t*, 6	+1ᵐ 7.06ˢ	+6′ 27.2″	6ʰ 17ᵐ 13.34ˢ	+36° 25′ 11.1″	9.367	0.098	+1.11ˢ	+0.5″
10 14 41 58	2	10, 8	−0 1.64	+1 14.1	6 17 26.73	+37 11 22.4	9.598	0.298	+1.17	+0.2
11 14 37 38	4	14*t*, 6	+0 25.74	−5 5.8	6 17 37.36	+37 59 47.4	9.609	0.286	+1.21	+0.3
18 14 16 9	5	1	..	+0 14.5	....	+43 19 8.0	..	0.075	+1.69	+0.7
18 14 11 55	5	10	0 8.53	.....	6 18 7.77	...	9.581	..	+1.69	+0.7
20 15 11 18	6	8, 9	+0 3.41	+1 37.3	6 18 1.16	+44 44 21.1	9.360	*n*8.821	+1.80	+0.7

Right-Ascension observations marked *t* were taken by transits; the others by micrometer measures.

Mean Places of Comparison-Stars for the beginning of the Year.

*	α	δ	Authority	*	α	δ	Authority
1	6ʰ 16ᵐ 2.17ˢ	+36° 18′ 43.4″	A.G. Lund 3252	5	6ʰ 18ᵐ 11.64ˢ	+43° 18′ 52.8″	A.G. Bonn 5220
2	6 17 27.20	+37 10 8.1	Comp. with 3 Δα − 1ᵐ13ˢ.35 Δδ − 1′36″.7	6	6 17 55.95	+44 42 16.1	Comp. with 7 Δα − 1ᵐ34ˢ.58 Δδ − 4′41″.9
3	6 18 10.55	+37 11 44.8	A.G. Lund 3275	7	6 19 30.53	+44 46 58.0	A.G. Bonn 5236
4	6 17 7.38	+38 4 52.9	A.G. Lund 3258				

OBSERVATIONS OF THE SATELLITES OF *MARS*,

MADE WITH THE 40-INCH TELESCOPE OF THE YERKES OBSERVATORY.

By E. E. BARNARD.

The following observations of the satellites of *Mars* were made under very unfavorable conditions of definition. In every case the planet was very blurred from bad seeing, so that it was impossible to set the wires on the limbs with any considerable degree of certainty. It was necessary to make some of the measures at large hour angles. Other work on the planet, which required the best definition, prevented the securing of a more extended series, or the beginning of observations earlier in the season. It is hoped, however, that the results may be useful. They can scarcely prove as accurate as the instrument would warrant under good conditions.

These measures have been reduced with the following apparent diameters, which were computed from my own measures of the planet, *A.N.* 3760, which are at distance unity:

Equatorial diameter = 9″.673 Polar diameter = 9″.581

	h	Appt. Equat. Diam. ″	Appt. Polar Diam. ″
Oct. 3		23.762	23.536
5	8	23.481	23.258
5	13	23.452	23.229
19		20.933	20.733
26		19.515	19.329
Nov. 2		18.087	17.915

In all the observations the phase was on the following limb of *Mars*. The following corrections for phase, which were taken from the *British Nautical Almanac* for 1909, have been applied to the f. limb in the reduction of the observed values to the center of *Mars:*

Date	Phase ″
Oct. 3	0.15
5	0.20
19	0.69
26	0.91
Nov. 2	1.08

All the measures are differences of right-ascension and declination, which are indicated by the letters p, f, and n, s, in the fourth column. They have not been corrected for refraction. The times, as usual, are Central Standard Times, which are $6^h\ 0^m$ slow of G.M.T. The measures were made with the aid of the smoked mica occulter.

Phobos.

Centr. S. T. h m s	From Limb ″	Reduced to Center ″	Limb	Comp.	Remarks
1909 *October* 3.					
8 16 24	4.61	+16.38	n	2	Satellite n.f.
8 18 17	29.57	+17.80	s	2	
8 20 24	10.46	+22.19	f	2	
8 21 54	34.87	+22.99	p	2	
8 53 0	4.45	+16.22	n	2	
8 54 40	29.59	+17.82	s	2	
October 5.					
8 29 20	13.99	− 2.36	n	4	Satellite s.p.
8 32 0	9.92	− 1.71	s	4	
8 35 18	12.63	−24.37	p	3	
8 38 55	38.01	−26.47	f	3	
8 59 12	3.73	− 7.90	s	4	
9 1 33	20.92	− 9.29	n	4	
9 5 6	16.69	−28.43	p	4	
9 7 19	40.99	−29.45	f	4	
13 12 15	24.04	+12.43	s	3	Satellite n.f.
13 14 50	1.10	+12.71	n	3	Sat. 2″ ± n. of limb.
13 18 27	15.93	+27.44	f	3	
13 21 5	40.11	+28.39	p	5	
October 26.					
9 53 0	12.17	−21.93	p	4	Satellite s.p.
9 55 5	32.65	−23.80	f	4	
9 58 14	15.14	− 5.48	n	5	
10 0 43	4.61	− 5.05	s	5	
1909 *November* 2.					
10 13 25	10.56	−19.60	p	5	Sat. s.p. V. difficult.
10 21 56	30.87	−22.91	f	5	“ “
10 30 10	15.90	− 6.94	n	5	“ “
10 34 1	2.53	− 6.43	s	5	n. of s. limb “ “
10 39 39	13.33	−22.37	p	4	Much better seen.
10 42 52	31.14	−23.18	f	5	“ “ “
10 47 19	18.86	− 9.90	n	4	Fairly well seen.

Deimos.

Centr. S. T. h m s	From Limb ″	Reduced to Center ″	Limb	Comp.	Remarks
1909 *October* 3.					
8 26 0	29.41	−41.29	p	2	Satellite n.p.
8 27 50	54.30	−42.57	f	2	
8 30 20	6.42	+ 5.35	n	2	
8 31 52	17.82	+ 6.05	s	2	
9 2 0	35.35	−47.23	p	2	
9 3 44	61.68	−49.95	f	2	
9 6 27	12.25	− 0.48	n	2	
9 7 44	12.58	+ 0.81	s	2	

Centr. S. T. h m s	From Limb ″	Reduced to Center ″	Limb	Comp.	Remarks
		1909 *October* 5.			
8 41 17	54.04	+65.58	f	4	Satellite n.f.
8 44 0	78.71	+66.97	p	4	
8 48 13	7.84	+19.47	n	4	
8 50 46	32.81	+21.18	s	4	
13 25 53	45.12	+56.64	f	4	
13 28 23	68.80	+57.08	p	5	
13 32 27	31.88	+43.49	n	4	
13 34 55	55.51	+43.90	s	4	
		October 19.			
11 50 39	28.68	−18.31	n	3	Satellite s.f.
11 52 47	5.05	−15.42	s	3	
11 56 24	28.06	+37.84	f	3	
11 58 43	48.88	+38.41	p	4	
		October 26.			
8 56 26	25.44	−35.10	s	4	Satellite s.p.
8 59 22	45.83	−36.17	n	5	
9 3 37	38.47	−48.23	p	5	
9 7 2	58.25	−49.40	f	5	
		1909 *November* 2.			
7 51 33	24.30	+33.24	n	4	Satellite n.f.
7 54 46	43.56	+34.60	s	4	13.8 mag.
7 58 26	35.27	+43.23	f	4	
8 1 10	52.61	+43.57	p	4	

1909 *Oct.* 3. $8^h\ 21^m$. *Phobos* 10^m ±. It is much brighter than *Deimos.*

$8^h\ 31^m$. Can just see both satellites with 12 inches aperture.

Oct. 5. $8^h\ 48^m$. Seeing very bad, limbs blurred. Satellites bright and easy. On the 3d *Phobos*, following, was very much brighter than *Deimos*, preceding. To-night this is not so marked There is a small star 1½′ preceding and north of *Mars* that is exactly the same brightness as *Phobos*. *Phobos* = 12 mag. *Deimos* = 12.3 mag.

$13^h\ 34^m$. Could not see satellites in open field with *Mars.* Both satellites bright = 11 mag. At the last measures *Deimos* was very slightly the brighter, but farther away from the planet. Seeing excessively bad. Limbs blurred and uncertain.

Oct. 19. $11^h\ 56^m$. Faint. Seeing excessively bad. Limbs only blurs.

Oct. 26. $9^h\ 7^m$. Faint in misty sky. Seeing very bad. Limbs very blurred and uncertain. Very high north-west wind.

$10^h\ 0^m$. Seeing very poor. Satellites about the same brightness. If the seeing were not so bad, they would be bright objects. With aperture of 25 inches can just faintly see them both.

Nov. 2. $8^h\ 1^m$. Faint, seeing very bad. Limbs very blurred.

Yerkes Observatory, 1909 *Nov.* 29.

DISCOVERY OF COMET a 1910.

Announcement by cable was received through *Harvard College Observatory*, January 17, from Johannesberg, South Africa, that a very bright Comet had been seen in full daylight about 10° S.S.W. of the Sun; also that an observer in the Orange Free State had seen the Comet two mornings previously.

The following position has been obtained by Dr. R. T. A. Innes, Director of the Observatory at Johannesberg:

G.M.T.	R.A.	Hly. Motion	Decl.	Hly. Motion
Jan. 16, 8119	$19^h\ 50^m\ 28^s$	$+0^m\ 41^s$	−25° 9′ 24″	+6′ 4″

A telegram from Lick Observatory announces that Wright observes bright Sodium line, D, in the Spectrum of the Comet.

A cablegram from Kiel, Jan. 23, gives the following Elements and Ephemeris by Dr. Kobold, based on observations of Jan. 18, 19 and 20:

Elements 1910.

T = 1910 Jan. 17.38
ω = 263° 6′
Ω = 8 56
i = 62 16
q = 0.041

Ephemeris for Berlin Noon.

1910	R.A. h m	Decl. ° ′	Light
Jan. 22	20 58	− 8 56	1.00
26	21 25	+ 0 20	
30	21 47	+ 7 45	
Feb. 3	22 6	+ 13 50	0.12

Ed.

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Discovery of Comet a 1910.

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MEAN PROPER-MOTION AS A FUNCTION OF SOLAR MOTION,

By H. RAYMOND.

The following paper leads to expressions for the mean proper-motions in terms of the solar motion and the mean *motus peculiaris* of the stars, under the assumption that the individual motions are at random. This problem was proposed to me by Professor Boss. It is incidental to his work upon precession and solar motion, which is based upon the means of the apparent angular proper-motions in different parts of the sky.

Let us assume that the distribution of the peculiar motions of the stars in a certain region of space is at random, and that it follows Maxwell's law for the distribution of the velocities of the particles of a gas: that is, that the number of stars the rectangular components of whose velocities lie between u and $u+du$, v and $v+dv$, w and $w+dw$, respectively, is proportional to

$$e^{-h^2(u^2+v^2+w^2)}\,du\,dv\,dw.$$

We will further assume all the stars to have a parallactic motion or drift, M, due to the motion of the Sun. If we imagine all of these stars, at an initial epoch, transferred to a point at the center of the region without change of motion, at the end of unit time they will be scattered through a globular space, surfaces of equal density being concentric spheres whose centers are displaced from the starting point or origin by the distance M.

Project this system upon a plane perpendicular to the line of sight. Let O be the projection of the origin, C that of the center of the spheres, and P that of an arbitrarily chosen star on the sphere of radius r. Let the angle between the line of sight and the peculiar motion of the star be φ. Put the angle $COP=\theta$, $OC=m$, $CP=s$, and $OP=\mu$. Neglecting the difference of perspective in which we see different parts of the region chosen, μ is the proper-motion of the star corresponding to P.

Let us confine our attention for a moment to those stars lying in the spherical shell whose radii are r and $r+dr$. If N be the total number of stars in the region, the number in this shell is $4h^3N\pi^{-\frac{1}{2}}r^2e^{-h^2r^2}dr$; the number per unit area on the shell, $Nh^3\pi^{-3/2}e^{-h^2r^2}dr$; and the number of projections P per unit area in the plane,

$$\frac{2Nh^3}{\pi^{3/2}\cos\varphi}e^{-{}^2r^2}\;dr.$$

Take polar coördinates, (μ,θ), in the plane of projection, with O as pole and OC as initial line. The area of the differential of surface is $\mu\,d\mu\,d\theta$. Noting that

$$\cos\varphi=\frac{\sqrt{r^2-s^2}}{r}=\frac{\sqrt{r^2-m^2+2m\mu\cos\theta-\mu^2}}{r},$$

we may write the number of projections P contributed to the differential area by the shell under consideration in the form

$$\frac{2Nh^3r\mu}{\pi^{3/2}\sqrt{(r^2-m^2+2m\mu\cos\theta-\mu^2)}}e^{-h^2r^2}d\mu\,d\theta\,dr.$$

Each of the corresponding proper-motions having the value μ, and there being N in all, it is clear that the mean value μ_1 of the proper-motions is

$$\mu_1=\frac{1}{N}\int\!\!\int\!\!\int\frac{2Nh^3r\mu^2}{\pi^{3/2}\sqrt{(r^2-m^2+2m\mu\cos\theta-\mu^2)}}e^{-h^2r^2}d\mu\,d\theta\,dr,\quad(1)$$

the limits of integration being so chosen as to include the whole system of projections.

The projection of the sphere of radius r is bounded by the circle whose equation is

$$\mu^2-2m\mu\cos\theta+m^2-r^2=0,$$

whence the limits of integration according to μ are

$\mu = m\cos\theta - \sqrt{(r^2 - m^2\sin^2\theta)}$ and $\mu = m\cos\theta + \sqrt{(r^2 - m^2\sin^2\theta)}$.

The limits of integration according to r are obviously

$$r = m\sin\theta \text{ and } r = \infty\ ;$$

and of the final integration.

$$\theta = -\frac{\pi}{2} \text{ and } \theta = +\frac{\pi}{2}.$$

We may now proceed with the integration:

$$(2)\quad \left\{\begin{aligned} \mu_1 &= \frac{2h^3}{\pi^{3/2}}\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} d\theta \int_{m\sin\theta}^{\infty} re^{-h^2r^2}\,dr \int_{m\cos\theta-\sqrt{(r^2-m^2\sin^2\theta)}}^{m\cos\theta+\sqrt{(r^2-m^2\sin^2\theta)}} \frac{\mu^2 d\mu}{\sqrt{(r^2-m^2+2m\mu\cos\theta-\mu^2)}} \\ &= \frac{h^3}{\pi^{\frac{1}{2}}}\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} d\theta \int_{m\sin\theta}^{\infty} r(3m^2\cos^2\theta - m^2 + r^2)\,e^{-h^2r^2}\,dr \\ &= \frac{1}{2h\pi^{\frac{1}{2}}}\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} (2h^2m^2\cos^2\theta + 1)\,e^{-h^2m^2\sin^2\theta}\,d\theta. \end{aligned}\right.$$

If we now put

$$e^{-h^2m^2\sin^2\theta} = \sum_{n=0}^{n=\infty}(-1)^n\frac{h^{2n}m^{2n}\sin^{2n}\theta}{n!},$$

where $n!$ is the product of all the integral numbers from 1 to n, our integral becomes

$$(3)\quad \left\{\begin{aligned} \mu_1 = \frac{1}{2h\pi^{\frac{1}{2}}}\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} &\left[2\sum_{0}^{\infty}(-1)^n\frac{h^{2n+2}m^{2n+2}\cos^2\theta\sin^{2n}\theta}{n!}\right. \\ &\left. + \sum_{0}^{\infty}(-1)^n\frac{h^{2n}m^{2n}\sin^{2n}\theta}{n!}\right]d\theta\ . \end{aligned}\right.$$

We make use of the following definite integrals:

$$\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} \cos^2\theta\sin^{2n}\theta\,d\theta = \frac{\pi}{2}\cdot\frac{1}{4}\cdot\frac{3}{6}\cdot\ \cdots\ \frac{2n-1}{2n+2}\ ;$$

$$\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} \sin^{2n}\theta\,d\theta = \frac{\pi}{2}\cdot\frac{3}{4}\cdot\frac{5}{6}\cdot\ \cdots\ \frac{2n-1}{2n}\ ;$$

$$\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} \cos^2\theta\,d\theta = \frac{\pi}{2}\ ; \qquad \int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} d\theta = \pi\ .$$

We now have

$$\left.\begin{aligned} \mu_1 = \frac{1}{2h\pi^{\frac{1}{2}}}\Bigg[& h^2m^2\pi + \pi \\ & + 2\sum_{1}^{\infty}(-1)^n\frac{h^{2n+2}m^{2n+2}}{n!}\,\frac{1\ .\ 3\ \ldots\ (2n-1)}{2\ .\ 4\ \ldots\ (2n+2)}\,\pi \\ & + \sum_{1}^{\infty}(-1)^n\frac{h^{2n}m^{2n}}{n!}\,\frac{1\ .\ 3\ \ldots\ (2n-1)}{2\ .\ 4\ \ldots\ (2n)}\,\pi\Bigg]. \end{aligned}\right\}\quad(4)$$

Combine the first term of the second series with $h^2m^2\pi$, the second with the first term of the first series, the third with the second of the first series, and so on. We get

$$\left.\begin{aligned} \mu_1 = \frac{\pi^{\frac{1}{2}}}{2h}\Bigg[1 + \frac{1}{2}h^2m^2 - \frac{1}{2\,.\,4\,.\,2\,!}h^4m^4 + \frac{1\,.\,3}{2\,.\,4\,.\,6\,.\,3\,!}h^6m^6 \\ - \frac{1\ .\ 3\ .\ 5}{2\ .\ 4\ .\ 6\ .\ 8\ .\ 4\,!}h^8m^8 + \ \ldots\ \Bigg] \end{aligned}\right)\quad(5)$$

It is plain that m, r, μ, and $\frac{1}{h}$ are quantities of the same kind, and as given in seconds per year they implicitly contain a factor inversely proportional to the distance that is, proportional to the parallax. Equation (5) is linear in these quantities, and obviously applies equally well, with a mere change of scale, to regions at other distances from us than the one considered, but along the same line of sight; hence it applies to the totality of such regions, that is, to all the stars lying in the same area of sky, μ_1, m, and $\frac{1}{h}$ having the values which correspond to the mean parallax of the stars concerned.

To find the mean proper-motion μ_0 of the stars all over the sky, we have

$$m = M \sin D\,,$$

where D is the distance of the region from the apex. Therefore, giving weights proportional to the areas on the celestial sphere,

$$\mu_0 = \frac{\dfrac{\pi^{\frac{1}{2}}}{2h}\displaystyle\int_0^{\frac{\pi}{2}}\left[\sin D + \tfrac{1}{2}h^2M^2\sin^3 D - \frac{1}{2\,.\,4\,.\,2\,!}h^4m^4\sin^5 D + \;.\;.\;.\;.\right]dD}{\displaystyle\int_0^{\frac{\pi}{2}}\sin D\,dD}\,. \qquad (6)$$

Making use of the definite integrals

$$\int_0^{\frac{\pi}{2}}\sin D\,dD = 1\,,$$

$$\int_0^{\frac{\pi}{2}}\sin^{2n+1}D\,dD = \frac{2\,.\,4\,.\,.\,.\,.\,2n}{1\,.\,3\,.\,5\,.\,.\,.\,.\,(2n+1)}\,,$$

this becomes

$$(7)\quad \mu_0 = \frac{\pi^{\frac{1}{2}}}{2h}\left[1 + \frac{h^2M^2}{1\,.\,3} - \frac{h^4M^4}{3\,.\,5\,.\,2\,!} + \frac{h^6M^6}{5\,.\,7\,.\,3\,!} - \;.\;.\;.\;.\right]$$

The number of peculiar motions whose values lie between r and $r+dr$ is $4Nh^3\pi^{-\frac{1}{2}}r^2e^{-h^2r^2}dr$; whence the mean value r_1 of r is

$$(8)\qquad r_1 = 4h^3\pi^{-\frac{1}{2}}\int_0^{\infty} r^3e^{-h^2r^2}dr = \frac{2}{h\pi^{\frac{1}{2}}}\,;$$

and

$$(9)\qquad hm = \frac{m}{2\pi^{\frac{1}{2}}r_1}\,.$$

μ_1 and μ_0 are most useful in the form of the ratios $\frac{\mu_1}{r_1}$ and $\frac{\mu_0}{M}$. Equations (5) and (7), with (8), readily give

$$(10)\quad \frac{\mu_1}{r_1} = \frac{\pi}{4}\left[1 + \frac{h^2m^2}{2} - \frac{h^4m^4}{2\,.\,4\,.\,2\,!} + \frac{1\,.\,3\,h^6m^6}{2\,.\,4\,.\,6\,.\,3\,!} - \;.\;.\;.\right]$$

and

$$(11)\quad \frac{\mu_0}{M} = \frac{r_1}{M}\cdot\frac{\pi}{4}\left[1 + \frac{h^2M^2}{3} - \frac{h^4M^4}{3\,.\,5\,.\,2\,!} + \frac{h^6M^6}{5\,.\,7\,.\,3\,!} - \;.\;.\;.\right].$$

We may now form Table I, giving the ratio $\frac{\mu_1}{r_1}$ in terms of $\frac{m}{r_1}$ as an argument, and Table II, giving $\frac{\mu_0}{M}$ in terms of $\frac{M}{r_1}$, by first computing h^2m^2 and h^2M^2 from the arguments by means of equation (9), and then $\frac{\mu_1}{r_1}$ and $\frac{\mu_0}{M}$ by (10) and (11) respectively.

TABLE I.
For a limited area.

$\frac{m}{r_1}$	$\frac{\mu_1}{r_1}$
0.00	0.785
.05	.787
.10	.790
0.15	0.797
.20	.805
.25	.816
0.30	0.830
.35	.846
.40	.864
0.45	0.884
.50	.906
.55	.930
0.60	0.956
.65	0.984
.70	1.013

TABLE II.
For the whole sky.

$\frac{M}{r_1}$	$\frac{\mu_0}{M}$
0.50	1.732
.51	.705
.52	.678
0.53	1.652
.54	.628
.55	.605
0.56	1.582
.57	.560
.58	.540
0.59	1.520
.60	.500
.61	.482
0.62	1.464
.63	.447
.64	.430
0.65	1.414
.66	.399
.67	.384
0.68	1.369
.69	.355
.70	.342

M is given, for example, by a determination of solar motion. μ_1 for different parts of the sky, and μ_0 for the whole sky, are obtained from the same data. $\frac{M}{r_1}$ may then be found by means of Table II; then $\frac{\mu_1}{r_1}$ from Table I. This procedure is easily modified to fit the hypothesis of two drifts. r_1 is now known, and μ_1 for each area of the sky. The values of μ_1 thus found, however, contain implicitly a factor proportional to the mean parallax of all the stars employed; whereas the observed value in any given area contains a factor proportional to the mean parallax of the stars in that area. Hence each area gives us the corresponding value of the ratio

$$\frac{\mu_1 \text{ observed}}{\mu_1 \text{ computed}} = \frac{p_1}{p_0};$$

where p_1 is the mean of the parallaxes of the stars in the given area, and p_0 is the mean of all the values of p_1, giving weights to each proportional to the area of sky.

ON THE VARIABILITY OF THE STAR 147 1907 *ARIETIS*,

DM $+11^\circ 305$; $2^h\ 9^m\ 36^s.8$; $+11^\circ\ 46'\ 18''$ (1900),

By PAUL S. YENDELL.

The variability of this star was announced in H.C.O. *Circular* No. 132; it was confirmed in a general way by Sperra, in a paper published in *Popular Astronomy*, Vol. XVI, p. 488. In September, 1909, in *A.N.*, No. 4352, Mr. Münch, from eighteen photometric observations, found a possible period of about eight days, with a probable maximum on 1908 Sept. 21.

I observed the star a few times in the late autumn and early winter of 1908, and in the fall of 1909 began a serious watch upon it, for the purpose of determining more satisfactory elements of variation, and the character of the star's light-curve. From 1909 Oct. 10 to 1910 Feb. 5, I have made eighty-five observations, on twenty-seven evenings, on two of which I observed fairly well-determined maxima.

From preliminary examination of Sperra's numerous observations, made during the autumn and winter of 1908-9, and from the observed intervals shown by my own observations between similar phases, I was pretty well convinced that the real period of the star was quite short, nearly commensurable with a day, and probably less than that value.

An application of such values in trial reductions resulted in the formation of a mean light-curve on the trial elements

Min. 1908 Nov. 20.555, Local M.T., $0^d.99248$ E.

In forming the mean light-curve from comparison with these elements, of the ninety-three observations at my disposal, only a single estimate was found entirely discordant, the rest forming a very consistent light-curve of the ordinary short-period type.

The light-range shown is $0^M.76$, from $8^M.28$ to $9^M.04$, being about that usual in variables of this type. The maximum follows the minimum at an interval of $0^d.348$. The maximum phase, though flat, is fairly well-determined, though the decline is slow at first, falling but about two-tenths of a magnitude in the four-tenths of a day immediately following the maximum; the final decrease to the minimum seems to be pretty rapid. The provisional elements finally adopted are:

Max. J.D. 2418267.121, Greenwich M.T. $0^d.99248$E.
m to *M*, $0^d.368$ (1908 Nov. 21.121).

These elements are strictly provisional, but appear to be probably as good as any attainable with the material at hand.

The comparison-stars and light-scale used are as follows:

		M	Lt.
a	DM + 11°300	7.6	19.7
e	+ 11°309	8.0	15.6
b	+ 11°307	8.3	10.6
c	+ 12°308	8.9	5.7
d	+ 11°304	9.5	0.0

The mean observed light-range is from 12.8 to 4.9 of this scale.

I have observed maxima

1909 Oct. 16.428	4	0.002
17.420	3	0.002

The comparisons are with the above elements.

Dorchester, Mass., 1910 *February* 6.

NEW VARIABLE IN *AQUILA*,

BD $-7^\circ 4896$ ($9^M.7$) ; $19^h\ 9^m\ 41^s.5$; $-7^\circ\ 11'.0$ (1900),

Communicated by Mary W. Whitney.

The star *BD* $-7^\circ 4896$ has been found by Dr. Caroline Furness of this observatory to be a variable. It is in the near vicinity of *W. Aquilae*, being but 15^s W. and 2′ N. of that star. During the period of observation the magnitude fell from the 10th to the 11th. The star then became too low in the horizon for further comparisons. The variability has been confirmed by Prof. Pickering from Harvard plates.

Vassar College Observatory, 1910 Feb. 7.

OBSERVATIONS OF COMET *a* 1910,

MADE AT ANN ARBOR WITH THE 12¼-INCH REFRACTOR,

BY W. J. HUSSEY.

Ann Arbor M.T.	*	Comp.	Δα	Δδ	App. α	App. δ	log pΔ		Red. to App. Pl.	
1910 h m s			m s	′ ″	h m s	° ′ ″			s	″
Jan. 24 5 58 31	1	7 , 6	−0 16.60	+13 42.1	21 13 9.25	−4 40 21.2	9.6421	0.7788	−1.93	−10.7
31 6 26 24	2	5 , 3	−3 54.07	− 0 25.6	21 36 8.82	+2 34 7.2	9.6353	0.7769	−1.88	−10.7
Feb. 3 6 32 35	3	8 , 5	+0 18.20	− 6 48.1	21 42 46.09	+4 29 58.9	9.6383	0.7659	−1.87	−10.7
4 6 15 53	5	8 , 8	+0 9.10	+ 7 59.1	21 44 39.35	+5 00 34.5	9.6367	0.7632	−1.86	−10.7
4 6 24 15	6	8 , 8	+0 18.09	+ 3 9.0	21 44 39.80	+5 00 40.1	9.6376	0.7641	−1.86	−10.7

Mean Places of Comparison-Stars for the beginning of the Year.

*	α	δ	Authority	*	α	δ	Authority
	h m s	° ′ ″			h m s	° ′ ″	
1	21 13 27.78	−4 53 52.6	Strassburg A.G. 7432	4	21 42 43.19	+ 4 41 42.5	Albany A.G. 7602.
2	21 40 4.77	+2 34 43.5	Albany A.G. 7593	5	21 44 32.11	+ 4 52 46.1	Albany A.G. 7614
3	21 42 29.76	+4 36 57.7	DM +4°4739 connected with *4.	6	21 44 23.57	+ 4 57 41.8	Albany A.G. 7613

The observations of Jan. 24 and Feb. 3 were obtained by measuring position-angle and distance; that of Jan. 31 by transits, and the last two by direct micrometer measures. The comet has decreased rapidly in brightness, but still on Feb. 3, the tail could be traced to a point about 18° from the head. Photographs obtained by Dr. CURTISS show two distinct branches of the tail, and besides some very faint streamers.

Ann Arbor, Mich., 1910 *Feb.* 5.

OBSERVATIONS OF COMETS,

MADE WITH THE 16-INCH REFRACTOR OF GOODSELL OBSERVATORY,

BY H. C. WILSON.

Local M.T.	Δα	Δδ	Comp.	App. α	App. δ	log pΔ		*
			COMET *a* 1909.					
1909 h m s	m s	′ ″		h m s	° ′ ″	s	″	
June 18 14 2 54	−1 11.2	−2 42.3	12 , 6	1 48 26.38	+33 15 5.3	......	......	1
			HALLEY'S COMET.					
Nov. 18 10 50 34	−1 1.22	−1 8.6	9 , 4	....	....	......	......	8
18 10 50 34	−3 16.20	−3 25.0	9 , 4	5 11 30.22	+16 34 54.2	*n*9.427	0.649	9
Dec. 7 10 6 39	−0 19.2	+1 26.8	5 , 4	4 0 1.2	+15 14 17.8	*n*8.958	0.633	7
8 10 7 15	−0 0.97	−6 12.3	3 , 6	3 55 38.89	+15 7 12.5	*n*9.870	0.634	6
18 10 26 47	+0 14.38	+4 14.1	9 , 6	3 11 26.02	+13 42 19.7	9.075	0.656	4
30 8 15 20	−0 16.13	+3 46.2	12 , 6	2 23 13.26	+11 45 47.7	8.712	0.675	2
1910 Jan. 5 8 26 36	−0 41.28	+5 20.4	12 , 6	2 2 36.65	+10 51 4.5	9.181	0.692	20
8 9 8 20	−0 22.08	+4 37.6	9 , 6	1 53 18.67	+10 25 54.7	9.404	0.709	19
14 8 20 2	−0 44.27	−5 7.6	9 , 6	1 37 5.34	+ 9 42 18.4	9.381	0.713	18
20 7 42 11	−1 0.30	−5 39.9	9 , 6	1 23 26.03	+ 9 7 1.6	9.378	0.719	17
1909			DANIEL'S COMET *e* 1909.					
Dec. 7 11 10 28	+0 2.3	+4 50.4	9 , 4	6 16 44.0	+34 47 37.7	*n*9.410	0.286	12
8 9 32 35	−0 11.32	+0 32.7	12 , 6	6 16 59.57	+35 34 27.6	*n*9.620	0.452	13
9 9 39 40	+2 16.34	+3 9.6	9 , 6	6 17 14.79	+36 24 22.7	*n*9.608	0.414	10
9 9 39 40	+1 8.46	+5 38.5	9 , 4	6 17 14.71	+36 24 22.5	*n*9.608	0.414	11
18 9 42 30	+0 19.58	+5 22.3	12 , 6	6 18 7.86	+43 22 7.1	*n*9.585	0.093	14
28 6 25 25	−0 25.06	+4 29.8	12 , 6	6 17 33.67	+49 24 38.8	*n*9.804	0.513	15
30 9 30 25	−0 22.01	−7 52.1	12 , 8	6 17 29	+50 29	*n*9.553	*n*9.247	16
1910 Jan. 5 9 47 13	+0 4.70	−0 46.2	9 , 6	6 17 27.38	+52 54 14.1	*n*9.429	*n*9.968	21
14 9 38 30	+0 11.56	−2 6.7	7 , 6	6 19 33.75	+55 13 31.1	*n*9.321	*n*0.163	22

Mean Places of Comparison-Stars for the beginning of the Year.

*	α 1909.0	Red to App.	δ 1909.0	Red to App.	Authority
	h m s	s	° ′ ″	″	
1	1 49 38.12	−0.42	+33 17 54.5	− 6.9	A.G. Leiden 707
2	2 23 26.51	+2.88	+11 41 45.8	+15.7	10^M Microm. comp. with No. 3.
3	2 24 1.56	+2.88	+11 35 49.4	+15.7	DM + 11°345. Toulouse phot. cat.
4	3 11 8.43	+3.21	+13 37 50.9	+14.7	10^M Microm. comp. with No.5
5	3 11 23.70	+3.21	+13 31 6.6	+14.7	Lalande 6036.
6	3 55 36 49	+3.37	+15 13 12.2	+12.6	Bordeaux phot. cat. 773
7	4 0 16.96	+3.58	+15 12 38.6	+12.4	Bonn VI + 15°577
8	5 12 28	......	+16 36	......	DM +16°744
9	5 14 43.24	+3.18	+16 38 12.2	+ 7.0	DM +16°755, Bonn Veröff. 4
10	6 14 54.32	+4.13	+36 21 12.5	+ 0.6	A.G. Lund +36°1407
11	6 16 2.12	+4.13	+36 18 43.5	+ 0.5	A.G. Lund +36°1410
12	6 16 37.69	+4.01	+34 42 46.8	+ 0.5	A.G. Leiden 2575
13	6 17 6.82	+4.07	+35 33 54.5	+ 0.4	Armagh$_2$ 780
14	6 17 43.60	+4.68	+43 16 44.3	+ 0.5	Lalande 12100
15	6 17 53.42	+5.31	+49 20 7.0	+ 2.0	Radcliffe 1717, Greenwich 10 yrs. 1081
16	6 17 46.0	+5.39	+50 37	+ 2.3	DM +50°1302
	1910.0		1910.0		
17	1 24 27.26	−0.93	+ 9 12 45.4	− 3.9	DM +8°238, Toulouse phot. cat.
18	1 37 50.38	−0.77	+ 9 47 28.9	− 2.9	DM +9°206, Toulouse phot. cat.
19	1 53 41.38	−0.63	+10 21 19.2	− 2.1	DM 10°264, Toulouse phot. cat.
20	2 3 18.47	−0.54	+10 45 45.7	− 1.6	DM 10°292, Toulouse phot. cat.
21	6 17 21.74	+0.94	+52 54 55.2	+ 5.1	10^M Microm. comp. with No. 23
22	6 19 19.92	+2.27	+55 15 30.7	+ 7.1	$9^M.5$ Microm. comp. with No. 25
23	6 19 59.74	+0.94	+52 57 47.1	+ 5.1	A.G. Harvard 2498
24	6 20 11.35	+2.27	+55 25 56.4	+ 7.1	$9^M.5$ Microm. comp. with No. 26
25	6 20 18.07	+2.27	+55 21 7.7	+ 7.1	DM +55°1078, Microm. comp. with No. 24
26	6 20 28.53	+2.27	+55 30 57.3	+ 7.1	A.G. Hels.-Gotha 4508

REMARKS.

Nov. 18. HALLEY'S Comet easily seen with faint illumination; measures good.

Dec. 7. Object glass of 16-inch telescope frosted over, so both Comets were exceedingly faint and difficult to measure.

Dec. 8. HALLEY'S Comet fairly bright, with nucleus of about 12th magnitude. DANIEL'S Comet fairly bright in 16-inch telescope, but has no nucleus.

Dec. 18. DANIEL'S Comet faint in 5-inch finder, but very plain with the 16-inch; condensation strong with almost stellar nucleus. HALLEY'S Comet easily seen in finder; in 16-inch has a 10.5 mag. nucleus. The bright part of the Comet is quite small, not more than 1′ in diameter, but the faint coma is perhaps 5′ in diameter, and a faint tail can be traced for at least 10′

Dec. 30. HALLEY'S Comet easily seen in 5-inch. Tail easily traced out of field of eye-piece of 16-inch; broad and spreading. Nucleus sharp and stellar; 10.5 mag. DANIEL'S Comet just visible in five-inch. In the 16-inch telescope round, with central condensation but no well-defined nucleus.

Jan. 5. HALLEY'S Comet not so bright as on Dec. 30; nucleus not brighter than 11th mag., and tail scarcely visible at all.

Jan. 14. HALLEY'S Comet large — fills nearly entire field of view of 16-inch telescope. Very faint streak of tail running out past the comparison-star DM + 9°206. Nucleus fairly sharp, — 11 mag. DANIEL'S Comet easily seen in finder; strong condensation, but no stellar nucleus.

Jan. 20. HALLEY'S Comet faint in moonlight. No nucleus, but pretty sharp condensation; measures are fair.

OBSERVATIONS OF HALLEY'S COMET AND NOTES ON ITS PHOTOGRAPHIC APPEARANCE,

BY E. E. BARNARD.

The following observations of HALLEY'S Comet are a continuation of those printed in *A.J.*, 605 and 607. As in the previous measures they were made with the large telescope.

The first visual observations of HALLEY'S Comet at this return were made with the 40-inch telescope by Professor BURNHAM on 1909 Sept. 15. My own observations did not begin until two days later.

1909–10 *C.S.T.		$\Delta\alpha$	$\Delta\delta$	Comp.	App. α	App. δ	Red to App.		*
	h m s	m s	′ ″		h m s	° ″ ′	s	″	
Dec. 28	10 30 42	−1 21.09	+0 47.6	18 , 6	2 30 21.33	+12 4 17.4	+2.94	+15.6	12
Jan. 6	9 38 27	+0 3.10	−3 5.6	5 , 7	1 59 17.5	+10 41.1	−0.58	− 1.8	13
8	9 37 33	−0 24.33	+4 31.8	24 , 9	1 53 16.39	+10 25 48.7	−0.63	− 2.1	14
9	9 40 10	+0 18.66	+0 37.5	6 , 8	1 50 15.7	+10 18.2	−0.65	− 2.2	15
11	6 21 50	....	+0 28.2	4	....	....	......	− 3.4	16
11	6 31 18	−0 17.83	....	8	....	....	−0.93	......	16
Feb. 1	7 50 58	+0 27.52	−3 18.4	22 , 8	1 2 26.54	+8 19 45.5	−1.20	− 5.5	17

* Central Standard Time, 6 hours slow of Greenwich Mean Time.

Mean Places of Comparison-Stars for 1909.0–10.0.

*	α	δ	Authority	*	α	δ	Authority
	h m s	° ′ ″			h m s	° ′ ″	
12	2 31 39.48	+12 3 14.2	Leipzig, A.G. 759	15	1 49 57.7	+10 17.6	BD +10°259
13	1 59 15.0	+10 44.2	BD + 10° 279 (ident.) 9ᴹ.2±	16	....	....	Star not ident. 9ᴹ or 10ᴹ
14	1 53 41.35	+10 21 19.0	Leipzig, A.G. 589	17	1 2 0.22	+ 8 23 9.4	Leipzig, A.G. 401

MEASURED $\Delta\alpha$ (COMET – STAR.)

1910 Jan. 6 + 45″.67
9 + 275.47
11 − 263.56

NOTES ON THE VISUAL APPEARANCE OF THE COMET.

1910 *Jan.* 6. $10^h\ 0^m$. There is a small star 1′ south of the comet. The nucleus is about one magnitude less than this star. The whole comet is about 10^M or 11^M. There is a diffusion following, that forms a very faint, short tail. Measures of a star south following the comparison star are: $\Delta\alpha + 0^m\ 26^s.18$ (8) , $\Delta\delta -0'\ 35''.6$ (3). Estimated mag. of this star = $8^M.5$.

Jan. 8. There is a faint nucleus about 13 mag. Surrounding this the head is bright for 15″ diameter. This gradually fades for 2′ diameter and is diffused and faint. Beyond this there seems to be a still fainter diffusion that fills the 5′ field. A feeble diffusion extends following and north for 5′ or 6′ — a diffused tail losing itself in the sky. The comet does not seem quite so bright to-night. Sky slightly misty.

Jan. 9. It is easy in the four-inch finder. In the large telescope there is a small nucleus and considerable diffusion from the head north following, forming a faint, diffused tail that stretches away beyond the width of the field. The comet is larger than the field of view, with very faint diffused nebulosity. The central brightness is ¼′ ± in diameter. It is beginning to look like a large comet now — from the appearance of the head and nucleus and the diffusion to form the tail.

Jan. 11. Comet excessively faint in thick sky.

Feb. 1. Nucleus about 12^M or 13^M in bright condensation. Head perhaps 10^M. The comet seems to fill the whole field (5′ diameter), with an extension north following. It is bright in the finder as a round, condensed spot of light.

NOTES ON PHOTOGRAPHIC RESULTS.

I have secured photographs of this comet at frequent intervals with the BRUCE doublet. The photographs of Dec. 29 show a short tail 10′ long, while in those of Feb. 3 a slender, straight tail 1° long is shown. The plates of Feb. 10 show nearly the same length of tail, but it is broader and better developed.

I have measured the diameter of HALLEY's Comet on the photographs of February 3 and 10, taken with the 10-inch BRUCE telescope. The result from both is a closely approximate diameter of 4′. This gives:

Feb. 3	Diameter	188,000	miles
10	"	194,000	"

Part of this increase may be real and part may be due to the difficulty of measurement. If we take the mean we have:

Feb. 6.5 Diameter 191,000 miles

The actual length of the tail on Feb. 3 as shown on the photograph, allowing for foreshortening, was about 5,000,000 miles. This is important as giving some idea of the probability of the tail being long enough on May 18 to envelope the Earth. Such a length of tail as above, so far from perihelion (over two months) would seem to show that the tail will almost certainly be long enough at the critical time (May 18) to reach to and beyond the Earth.

OBSERVATIONS OF A NEBULA NEAR HALLEY'S COMET.

While observing the comet on January 9, I found a very small cometary-looking nebula of about the 14th magnitude, and 5″ diameter. It was much brighter in the middle to probably a faint nucleus. A half hour's watch failed to show any motion. The nebula was exactly south of a 13th magnitude star. Its position was measured with reference to this star:

Nebula-star $\Delta\alpha$ −0′ 0″.6 (2) (in arc)
$\Delta\delta$ −0′ 28″.6 (2)

The 13th magnitude star was referred to star 15 (HALLEY's Comet).

13 mag. star −No. 15 $\Delta\alpha$ $+1^m\ 19^s.60$ (2tr)
$\Delta\delta$ +4′ 26″.9 (1)

The approximate place of the nebula (which seems to be new) is therefore:

1910.0 $1^h\ 51^m\ 17^s.3$ +10° 21′.6

Yerkes Observatory, 1910 *February* 11.

ELEMENTS OF COMET *a* 1910,

BY W. J. HUSSEY.

With the assistance of Dr. CURTISS and Mr. VINTON, I have computed five systems of elements of this comet, none of them representing the middle place, as follows:

T	ω	☊	i	log q	From Observations on	Computers
	° ′	° ′	° ′			
1910 Jan. 27.42	42 28	113 10	139 12	9.6186	Jan. 16, 19, 22	HUSSEY and VINTON
37.08	92 14	115 34	126 00	9.4740	16, 22, 24	HUSSEY and VINTON
38.38	87 31	115 23	122 25	9.5218	20, 24, 31	HUSSEY and CURTISS
27.20	40 59	112 34	129 35	9.5888	21, 31, 35	HUSSEY and CURTISS
22.59	20 44	110 3	131 34	9.5437	24, 31, 38	HUSSEY

The residuals for these orbits are all larger than can be attributed to errors of observation, which renders it probable that the comet is not moving in a parabola. An attempt to compute elliptic elements by GAUSS's method from the observations of Jan. 16, 24 and 31, led to results which seemed to indicate that these observations are insufficient for the determination of the orbit. From the observations of Jan. 24, 31, 35, Dr. CURTISS has obtained hyperbolic elements, but they do not satisfactorily represent the observations.

From the physical appearance of the comet, we should expect a somewhat earlier date of perihelion passage than indicated by the elements given above, say about Jan. 17, and a smaller perihelion distance. But it will be seen that different sets of observations lead to nearly the same results. The observations of Jan. 24, 31, 35, and 38 are from my own micrometric measurements from comparison stars in the usual manner.

Ann Arbor, Michigan, 1910 *Feb.* 12.

COMET *a* 1910.

Recent numbers of the *Astronomical Bulletins*, issued from the Harvard College Observatory, give orbits quite similar to those obtained by Prof. HUSSEY in this number of the *A.J.* The following is by Prof. H. A. HOWE, of the University of Denver.

$$T = 1910 \text{ Jan. } 19.16 \text{ Berlin Time.}$$

$$\omega = 53^\circ\ 37'.6$$

$$☊ = 114\ 23.3$$

$$i = 130\ 10.5$$

$$\log. q = 9.5870$$

This orbit was based on Prof. HOWE's observations of Jan. 16, Jan. 24, and Feb. 1. He remarks that the middle place is badly represented; and this appears to have been the experience of other computers.

Among recent observations of Comet *a* 1910 contained in the *Astronomical Bulletins*, are two made by Prof. O. C. WENDELL, of the Harvard College Observatory, using the square-bar micrometer. These are not corrected for refraction.

G.M.T. 1910	$\Delta\alpha$	$\Delta\delta$	App. α	App. δ	Comp. Star.
h m s	m s	′ ″	h m s	° ′ ″	
Feb. 6 11 18 47	−0 37.5	+0 16.3	21 48 11.7	+5 59 44	Leip. A.G., 10995
Feb. 10 11 21 28	−2 15.2	−7 56	21 54 26.0	+7 41 32	Leip. A.G., 11071

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COMET *a* 1910.

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OBSERVATIONS OF SATURN, ECLIPSES AND MEASURES OF THE SATELLITES, AND POSITION-ANGLES OF THE RING,

By E. E. BARNARD.

ECLIPSES OF THE SATELLITES.

These observations were made at the request of Professor Hermann Struve. Every opportunity was taken advantage of to secure as many observations as possible, but circumstances were such that only the results given here were obtained.

I tried to observe the eclipses of both *Mimas* and *Enceladus*, but the conditions were not good enough to permit of seeing them anywhere near the point of eclipse. I am unable to tell what could be done with them on a first-class night. The proximity to the disk of *Saturn* makes a very great difference in the apparent brightness of any of the satellites. As an instance of this effect, we will take the case of *Rhea* at the observations of 1906 July 29. When the planet was first observed at 13ʰ10ᵐ, *Rhea* was bright, and was estimated to ½ mag. or ¾ mag. less than *Dione*, which was following the ring. The seeing was very poor. As the satellite approached the planet it lost very much in brightness, due alone to the proximity of *Saturn*. This became very marked as it drew nearer to the limb, and almost led one to think several times that the eclipse had begun.

Frequent notes were made as to the relative brightness of *Rhea* and *Dione*. The approach to the planet finally caused a loss of 2 magnitudes, or 2½ magnitudes, in the light of *Rhea*, before the eclipse began.

In the observations of the eclipses, given below, most of the records have been omitted for the sake of brevity.

1906 July 29.

Eclipse of *Rhea*. (Disappearance.)

h	m	s	
13	43	36	Still distinct, but very faint. Seeing poor.
13	44	36	3 mag. less than *Dione*. Very close to limb, distant 2″±.
13	48	6	Very faint and close to limb, but distinct. 3 mag. less than *Dione*.
13	49	16	Very faint, but quite distinct. Think it is in the shadow.
13	50	11	Very faint. Think it is fading rapidly.
13	50	46	Very faint. Just faintly visible; certainly in shadow. It is a small bright point.
13	51	21	Excessively faint.
13	51	51	Cannot see it.
13	52	16	Certainly disappeared.

From the observations, I have assumed the middle of the disappearance at 13ʰ 51ᵐ 2ˢ.

1906 August 3.

Eclipses of *Tethys* and *Dione*.

Eclipse of *Tethys*. (Disappearance.)

At 14ʰ 50ᵐ the satellites were very close together, *Tethys* being slightly south following. In moments of steadiness they were just separate — about 1″ apart. The two were exactly alike. Frequent comparisons of their relative light showed that no certain change took place in *Tethys* until 15ʰ 11ᵐ–12ᵐ.

15	10	41	Same brightness.
	11	41	Fading.
	12	1	$\frac{1}{10}$ mag. less than *Dione*.
	12	16	½ mag. less than *Dione*.
	12	31	1 mag. less than *Dione*.
	12	46	Gone. Seeing good.
	13	11	Certainly gone.

From these observations I would put the middle of the disappearance at 15ʰ 12ᵐ 14ˢ, or perhaps slightly earlier.

The observations of *Dione* were less certain. There was no suitable object for comparison, and the seeing was frequently poor.

Eclipse of *Dione*. (Disappearance.)

$15^h 19^m 31^s$	Unchanged.
20 1	Fading.
20 16	0.5 gone.
20 31	0.6 gone.
21 1	Very faint.
21 6	Very, very faint.
21 21	Excessively faint.
21 36	Gone.
22 11	Certainly gone.

The seeing averaged 3 on a scale of 5. Frequent disturbances in the air blotted the satellite out at the critical time. I think that perhaps the time of middle disappearance would not be far from $15^h 20^m 43^s$, though the times of "0.5 gone" and "0.6 gone" would place it a little earlier.

1906 October 16.

Eclipse of *Tethys*. (Reappearance.)

9 1 17	First distinctly seen; perhaps saw it a few seconds earlier. Seeing very bad.
9 1 55	Same brightness as *Rhea* (?) north preceding.
9 3 12	Do not think it is any brighter than at $9^h 1^m 55^s$.
9 4 32	It is $0^M.1$ brighter than *Rhea* (?).

The seeing was very bad just before the reappearance of the satellite.

1906 October 30.

Eclipse of *Dione*. (Reappearance.)

8 35 25	First seen.
8 36 10	½ as bright as *Tethys*, following.
8 37 25	¾ as bright as *Tethys*, following.
8 38 45	Unchanged.

The seeing was excessively bad, and it may be that the first observation was 3^s or 4^s late. Magnifying power 160, with occulter.

1906 December 8.

Eclipse of *Tethys*. (Reappearance.) Through clouds.

5 56 39	Think I saw the satellite feebly in a momentary break in the clouds.
6 3 14	A clear space passed and the satellite was apparently at full brightness.

1907 December 12.

Eclipse of *Dione*. (Reappearance.)

$6^h 13^m 38^s$	First seen; perhaps several seconds late, as it came out close to the ring.
6 14 3	Feebly brighter.

1908 August 16.

Eclipse of *Tethys*. (Disappearance.)

13 3 27	Fading (?).
13 3 57	Fading (?).
13 4 27	Fading certainly.
13 5 27	Fading certainly.
13 5 42	½ gone.
13 5 57	¾ gone.
13 6 12	Very faint.
13 6 27	Very faint.
13 6 47	Gone. Cannot see it. Sky thick about this time.

1908 August 16.

Eclipse of *Enceladus*. (Disappearance.)

13 8 47	Still visible.
13 9 27	Still visible, but faint, in haze. A few seconds later the planet was covered with dense haze, and the eclipse was lost.

1908 September 4.

Eclipse of *Tethys*. (Disappearance.)

10 14 5	Still visible.
10 14 30	Still visible.
10 14 45	Still visible.
10 15 5	Cannot see it.
10 15 35	Still visible, but very faint.
10 16 5	Cannot see it.

Could not see it after $10^h 15^m 35^s$. Think it disappeared soon after that record. Planet low, and seeing poor, but better at last observation. Magnifying power, 700.

MEASURES OF THE RELATIVE POSITIONS OF THE SATELLITES.

1906 August 11.

Dione and *Enceladus*.

h m s	Pos. Ang. °	Dist. ″	Cps.
13 42 40	98.52	. . .	5
13 47 40	.	19.40	4
13 51 34		19.36	4

Dione and *Mimas*.

h m s	Pos. Ang. °	Dist. ″	Cps.
13 57 23	107.76		5
14 1 36		15.40	4
14 4 44		15.04	4

Seeing very bad in each case.

1906 September 4.

Tethys and *Dione*.

h m s	Pos. Ang. °	Dist. ″	Cps.
12 12 18	220.38	. . .	5
12 16 4	.	8.02	4

Rhea and *Enceladus*.

h m s	Pos. Ang. °	Dist. ″	Cps.
12 20 14	272.90		5
12 24 44		44.48	5

Seeing fair.

1906 September 8.

Dione and *Enceladus*.

h m s	Pos. Ang. °	Dist. ″	Cps.
13 27 38	201.94	.	5
13 32 12		6.47	4

Telescope swaying badly.

1906 December 18.

Dione and *Enceladus*.

h m s	Pos. Ang. °	Dist. ″	Cps.
5 20 44	148.19	. .	5
5 23 39	. . .	4.09	4
5 25 44		4.07	4

1907 August 6.

Tethys and *Enceladus*.

h m s	Pos. Ang. °	Dist. ″	Cps.
14 50 58	88.22	. .	5
14 54 29		8.93	4
14 57 20		8.52	4

Rhea and *Tethys.*

h m s	Pos. Ang. °	Dist. ″	Cps.
15 1 56	266.49	....	6
15 5 27	..	19.61	4
15 7 44	...	19.32	4

1907 August 11.

Dione and *Enceladus.*

h m s	Pos. Ang. °	Dist. ″	Cps.
14 24 47	275.45	....	5
14 28 38	.....	20.50	4
14 31 47	.....	20.71	4

Titan and *Dione.*

h m s	Pos. Ang. °	Dist. ″	Cps.
15 2 28	277.58	..	5
15 5 57	.....	62.39	4
15 8 44	.....	61.95	4

1907 August 13.

Dione and *Rhea.*

h m s	Pos. Ang. °	Dist. ″	Cps.
12 58 26	94.53	..	2*
13 8 33	94.87	...	3
13 14 20	94.81	...	3
13 28 37	...	59.68	4
13 32 26	....	59.35	5

1907 August 20.

Rhea and *Enceladus.*

h m s	Pos. Ang. °	Dist. ″	Cps.
11 41 31	101.46	....	5
11 45 44	.....	11.18	4
11 46 22	....	11.30	4

Dione and *Enceladus.*

h m s	Pos. Ang. °	Dist. ″	Cps.
11 52 31	98.97	....	5
11 55 28	....	32.07	4
11 58 52	....	32.05	5

Rhea and *Tethys.*

h m s	Pos. Ang. °	Dist. ″	Cps.
12 55 7	95.33	.....	5
12 59 38	....	100.65	4
13 3 29	....	101.10	4

---

* Clouds.

1907 September 1.

Titan and *Rhea.*

h m s	Pos. Ang. °	Dist. ″	Cps.
12 9 8	268.22	....	.
12 14 51	.....	28.68	4
12 17 55	....	28.41	4

Dione and *Tethys.*

h m s	Pos. Ang. °	Dist. ″	Cps.
12 23 5	91.19	...	4
12 27 37	....	23.56	4
12 31 5	....	22.88	4

1907 September 3.

Titan and *Dione.*

h m s	Pos. Ang. °	Dist. ″	Cps.
12 28 38	137.20	.	5
12 32 8	....	2.94	4
12 34 0	......	2.74	4

Titan and *Tethys.*

h m s	Pos. Ang. °	Dist. ″	Cps.
12 36 39	236.25	...	5
12 39 18	.....	3.50	4
12 41 33	.....	3.91	4

Titan and preceding end of ring.

h m s	Pos. Ang. °	Dist. ″	Cps.
12 47 0	105.89	....	2
12 48 19	.....	14.09	2
12 49 39	.....	14.19	2

1907 September 8.

Dione and *Tethys.*

h m s	Pos. Ang. °	Dist. ″	Cps.
11 11 49	101.83	....	5
11 15 46	.....	11.32	4
11 18 52	.....	11.22	4

Rhea and *Enceladus.*

h m s	Pos. Ang. °	Dist. ″	Cps.
11 35 8	93.17	....	5
11 40 17	....	52.73	4
11 43 49	....	52.50	4

1907 September 10.

Titan and *Mimas.*

h m s	Pos. Ang. °	Dist. ″	Cps.
11 18 58	306.28	...	5
11 22 21	.....	7.25	5
11 24 55	.....	7.28	5

Tethys and *Dione.*

h m s	Pos. Ang. °	Dist. ″	Cps.
11 32 27	95.93	...	5
11 35 11	....	4.24	4
11 37 51	....	4.62	4

1907 October 13.

Rhea and *Mimas.*

h m s	Pos. Ang. °	Dist. ″	Cps.
11 42 56	63.20	...	5
11 45 38	..	2.99	3
11 47 24	.	3.20	4

1907 November 5.

Dione and *Tethys.*

h m s	Pos. Ang. °	Dist. ″	Cps.
8 50 41	77.55	...	6
8 55 5	.	7.88	4
8 57 40	.	8.02	4

1907 November 28.

Titan and *Rhea.*

h m s	Pos. Ang. °	Dist. ″	Cps.
6 26 45	186.28	...	5
6 30 17		3.40	4
6 31 43	.	3.18	4

1907 December 5.

Tethys and *Enceladus.*

h m s	Pos. Ang. °	Dist. ″	Cps.
5 13 16	99.04	....	5
5 16 00	....	14.52	4
5 18 00	....	14.44	4

1907 December 25.

Tethys and *Enceladus.*

h m s	Pos. Ang. °	Dist. ″	Cps.
5 50 42	244.30	...	5
5 54 2	.....	1.95	4
5 55 57	.....	1.98	4

1908 August 18.

Titan and *Rhea.*

h m s	Pos. Ang. °	Dist. ″	Cps.
13 30 3	176.94	....	5
13 35 19	.....	29.60	4
13 38 00	.....	29.45	2*

---

* Clouds.

Through the courtesy of Professor Updegraff I am greatly obliged to Mr. James Robertson of the *Nautical Almanac* office, for the identification of the satellites in the above measures.

OBSERVATIONS OF THE POSITION-ANGLES OF THE RINGS.

Advantage was taken of the linear condition of the rings of *Saturn* near the time of their recent disappearance to make a series of measures of their position-angles. The observations were all made with the large telescope, and are not corrected for refraction. In the observations of 1907 July 2 and December 12, the dark side of the rings was turned toward us and they were therefore not visible by direct sunlight. Why they were visible at all under these conditions I have tried to explain in *Monthly Notices, R.A.S.*, Vol. LXVIII, page 356, and Vol. LXIX, page 623.

Previous measures of the position-angles of the rings were made by the writer when the rings were in a similar condition in 1891 on 30 nights, from March 23 to August 14, with the 12-inch equatorial of the Lick Observatory (*Astronomical Journal*, Vol. XI, No. 246, pp. 42-43). Another series was made with the same instrument on 11 nights, from 1891 October 22 to 1892 March 16 (*Monthly Notices, R.A.S.*, Vol. LII, page 422, for April, 1892). The present measures are given below.

		h m	Pos.Angs. °	Cps.	
1906 July	21	15 20	95.34	6	
	24	15 22	95.22	5	
	29	15 30	95.21	5	
Aug.	21	14 45	95.09	6	
	25	15 30	95.43	5	In haze.
Sept.	4	12 00	95.97	6	Seeing very poor.
	8	13 15	95.40	5	
	11	13 10	95.15	5	Seeing excessively bad.
	15	13 25	95.18	5	Seeing very bad.
	25	12 40	95.10	5	Seeing excessively bad.
Oct.	2	9 00	95.74	5	Seeing excessively bad.
Oct.	13	8 35	95.87	5	
	27	7 30	95.74	5	Seeing very poor.
Dec.	8	7 00	95.89	5	Difficult. Through clouds.
	18	5 10	95.68	5	Through clouds.
1907 July	2	15 20	94.59	4	Luminous trace of rings on sky.
Aug.	6	13 30	94.72	6	
	11	12 45	94.28	5	Very blurred.
	13	11 50	94.28	6	Seeing excessively bad.
	20	11 35	94.43	10	Seeing fair.
Sept.	1	11 10	94.75	5	
	3	14 10	94.66	5	Image breaking badly.
	8	10 50	94.39	5	Through thick haze.
	10	12 00	95.10	6	Seeing bad.
Oct.	1	11 05	94.84	7	Seeing very bad.
	13	12 00	94.78	5	
Dec.	12	4 55	95.44	5	Seeing fair.
1908 June	19	15 45	93.21	6	Seeing fair.

In all the observations of this paper the times are $6^h\ 0^m$ slow of G.M.T.

OBSERVATIONS OF MINOR PLANETS AND OF COMET 1909 *a*,

MADE AT THE DETROIT OBSERVATORY, ANN ARBOR, WITH THE 12¼-INCH TELESCOPE,

By GEO. A. LINDSAY.

1909 Ann Arbor M.T.	*	Comp.	Δα	Δδ	App. α	App. δ	log pΔ		Red. to App. Pl.	
					(19) *Fortuna.*					
h m s			m s	′ ″	h m s	° ′ ″			s	″
July 16 12 29 15	1	8, 8	−0 5.15	+ 9 28.9	19 59 40.95	−17 52 55.7	8.156	0.882	−2.23	+4.4
19 12 42 11	3	8, 8	+0 19.32	− 6 41.1	19 56 41.62	−18 1 0.9	8.833	0.881	+2.27	+4.3
21 12 40 50	5	19, 8	+0 50.02	+ 5 57.1	19 54 40.71	−18 6 19.6	8.893	0.880	+2.29	+4.2
23 11 31 8	5	20, 8	−1 7.64	+ 0 36.8	19 52 43.05	−18 11 39.9	n8.516	0.882	+2.29	+4.2
					(46) *Hestia.*					
July 9 12 19 22	6	8, 8	−0 39.57	+ 7 14.0	18 22 11.62	19 23 34.6	9.125	0.883	+2.16	−0.6
12 12 7 41	7	8, 8	+0 41.25	− 0 19.7	18 19 24.52	−19 26 48.1	9.143	0.878	+2.15	−0.7
14 11 19 2	8	8, 8	−0 26.22	− 5 7.0	18 17 38.26	−19 28 54.6	8.788	0.879	+2.17	−0.6
15 11 32 7	9	8, 8	−0 14.97	+ 2 11.2	18 16 45.94	−19 30 1.9	8.979	0.885	+2.18	−0.6
16 11 16 29	10	8, 8	+0 7.69	+ 2 2.6	18 15 55.17	−19 31 7.1	8.870	0.887	+2.19	−0.8
19 10 15 14	12	8, 8	−0 9.30	− 5 6.5	18 13 30.68	−19 34 11.8	n8.322	0.888	+2.19	−1.0
21 10 25 19	13	8, 8	−0 19.93	+ 5 16.0	18 11 59.01	−19 37 4.1	8.328	0.888	+2.18	−1.1
					COMET DANIEL, 1909 *a*.					
July 16 11 14 5	14	8, 8	−0 5.06	+ 4 7.3	3 37 12.00	+60 7 16.9	n9.919	0.494	−0.55	8.4
23 14 21 44	15	8, 8	−0 42.07	+ 6 54.5	4 12 37.56	+63 13 36.9	n9.990	0.353	−0.49	−8.5

Mean Places for 1909.0 of Comparison-Stars.

*	α	δ	Authority
	h m s	° ′ ″	
1	19 59 43.87	−18 2 29.0	8.9 mag. con. with *2
2	19 57 16.62	−18 9 28.1	Kam. 3927
3	19 56 20.03	−17 54 24.1	9.5 mag. con. with *1
4	19 56 38.33	−17 48 7.1	Wash. A.G. Catal. 7523
5	19 53 48.40	−18 12 20.9	Rad$_3$ 5342
6	18 22 49.03	−19 30 48.0	Weiss's Argel. 11395
7	18 18 11.12	−19 26 27.7	Rad$_3$ 4811
8	18 18 2.31	−19 23 47.0	Connected with *7
9	18 16 58.73	19 32 42.5	Connected with *7
10	18 15 15.29	−19 33 8.9	Connected with *11
11	18 15 38.11	19 11 51.2	Weiss's Argel. 11267
12	18 13 37.79	19 29 34.3	Weiss's Argel. 11222
13	18 12 16.76	−19 42 19.0	Rad 1777
14	3 37 17.61	+60 3 18.0	Helsingfors-Gotha A.G. Catal. 408
15	4 13 20.12	+63 36 50.9	Helsingfors-Gotha A.G. Catal. 3477

OBSERVATIONS OF MINOR PLANETS AND COMETS,

MADE WITH THE 16-INCH EQUATORIAL AT THE CINCINNATI OBSERVATORY,

BY J. G. PORTER AND EVERETT I. YOWELL.

1908–09	Cin. M.T.	*	Comp.	Δα	Δδ	App. α	App. δ	log pΔ		Red. to App. Pl.	
							Comet 1908 *c*.				
	h m s			m s	′ ″	h m s	° ′ ″			s	″
Sept. 28	9 47 51	1	6 , 6	+0 36.03	+ 5 31.4	21 55 34.04	+74 11 43.1	9.211	*n*0.701	+3.71	+19.8*
Oct. 1	8 8 23	3	8 , 6	+1 47.76	+ 4 45.6	21 8 54.26	+71 23 34.0	*n*9.073	*n*0.670	+2.39	+21.4*
3	7 34 59	4	8 , 6	+1 31.96	− 1 20.3	20 44 3.15	+69 1 31.2	*n*9.039	*n*0.641	+1.76	+23.2*
3	7 34 59	5	6 , 6	−0 1.77	+ 1 26.6	20 44 3.16	+69 1 28.9	*n*9.039	*n*0.641	+1.79	+23.2*
5	8 13 9	6	6 , 6	2 0.85	+ 5 20.0	20 23 23.88	+66 16 5.9	9.364	*n*0.590	+1.36	+23.5*
12	7 49 40	7	10 , 6	+0 8.88	+ 0 54.7	19 38 8.37	+55 4 58.0	9.512	*n*0.289	+0.63	+22.9*
31	8 49 26	8	8 , 6	−1 11.71	− 8 51.0	18 58 20.64	+23 20 53.3	9.662	0.607	+0.54	+14.7*
1909							(241) *Germania*. Mag. 11.				
Apr. 24	9 29 29	9	8 , 6	−0 7.51	−11 59.4	13 40 4.26	−17 50 8.2	*n*9.381	0.849	+1.15	− 7.7*
27	8 44 26	10	8 , 8	−0 35.32	− 1 30.4	13 37 49.25	−17 34 50.7	*n*9.468	0.838	+1.17	8.0*
May 5	9 18 14	11	10 , 8	−0 12.72	− 1 5.2	13 32 5.08	−16 52 26.1	*n*9.215	0.844	+1.14	− 8.2*
							(37) *Fides*. Mag. 10.				
Apr. 24	9 57 22	12	8 , 6	+0 13.99	− 0 46.7	13 18 44.72	− 9 53 17.1	*n*9.151	0.816	+1.09	− 7.5*
27	8 15 13	13	8 , 8	+0 39.80	+ 1 43.9	13 16 22.20	− 9 41 11.6	*n*9.472	0.801	+1.11	− 7.6*
							(270) *Anahita*. Mag. 11.				
Apr. 24	10 34 18	14	8 , 6	+1 29.04	− 7 39.7	13 42 51.33	−13 42 8.3	*n*9.072	0.840	+1.13	7.5*
27	9 4 2	15	8 , 8	−0 19.31	+ 1 43.5	13 39 52.74	−13 22 27.3	*n*9.413	0.825	+1.14	− 7.7*
							(532) *Herculina*. Mag. 9.				
May 28	9 17 46	16	9 , 6	−0 9.36	+ 2 59.3	17 19 13.93	− 7 57 29.8	*n*9.573	0.779	+1.51	− 1.6*
29	9 51 31	16	8 , 6	−1 5.21	− 0 33.6	17 18 18.09	− 8 1 2.6	*n*9.510	0.788	+1.52	− 4.5*
June 5	9 8 45	17	8 , 6	+0 51.66	+ 4 58.6	17 11 45.14	− 8 28 58.6	*n*9.527	0.789	+1.64	− 4.0*
							(444) *Gyptis*. Mag 11.				
May 29	10 30 52	18	8 , 6	+2 14.92	+ 0 1.3	17 31 58.12	9 54 49.9	*n*9.457	0.803	+1.52	− 4.2*
June 5	9 36 15	19	10 , 6	+0 20.89	− 4 51.9	17 23 39.66	− 8 39 51.1	*n*9.497	0.793	+1.64	− 3.7*
7	9 52 1	20	8 , 6	+1 1.80	+ 2 53.1	17 21 56.44	− 8 32 39.5	*n*9.439	0.798	+1.67	− 3.7*
							Comet 1909 *a*.				
June 18	14 56 33	21	8 , 6	−1 9.51	− 1 39.3	1 48 28.21	+33 16 8.5	*n*9.724	0.570	0.41	− 6.9*
19	14 28 28	22	10 , 6	+0 31.73	+ 3 30.7	1 51 21.41	+34 36 39.6	*n*9.740	0.609	−0.40	− 7.1*
22	14 3 23	23	10 , 6	−0 21.65	+ 2 32.2	2 0 33.05	+38 30 18.5	*n*9.765	0.624	−0.39	− 7.5*
26	14 42 43	24	10 , 6	+0 21.22	+ 4 43.9	2 13 59.09	+43 19 10.0	*n*9.788	0.483	0.41	− 8.1*
28	14 33 31	25	12 , 8	+1 31.42	− 0 13.9	2 21 4.31	+45 30 41.0	*n*9.808	0.482	−0.41	8.4*
							(79) *Eurynome*. Mag. 9.5.				
Oct. 30	8 49 32	26	12 , 6	−0 46.49	−11 18.3	2 51 7.07	+14 3 31.0	*n*9.566	0.636	+2.89	+15.5*
Nov. 2	9 1 35	27	12 , 6	+0 50.55	− 2 59.3	2 48 37.14	+13 40 37.9	*n*9.520	0.626	+2.92	+15.8*
10	8 34 3	28	8 , 6	+1 40.20	− 6 32.9	2 41 53.07	+12 40 34.3	*n*9.498	0.631	+2.96	+16.2*
							(68) *Leto*. Mag. 10.				
Nov. 11	9 39 46	29	12 , 6	−0 29.34	+ 7 11.5	4 9 11.69	+24 12 16.1	*n*9.561	0.493	+3.22	+11.1*
13	9 42 2	30	12 , 6	+0 44.13	+ 2 16.9	4 7 10.21	+24 14 14.4	*n*9.539	0.478	+3.27	+11.4*
24	9 1 55	31	8 , 6	−1 8.25	+ 4 50.9	3 55 34.45	+24 18 57.5	*n*9.507	0.460	+3.41	+12.7*
							(50) *Virginia*. Mag. 10.5.				
Nov. 26	14 25 8	32	8 , 6	+0 11.59	+16 57.8	4 34 21.49	+16 51 37.1	9.418	0.560	+3.32	+10.3*
27	8 12 44	32	12 , 6	−0 31.97	+15 2.9	4 33 37.95	+16 49 42.1	*n*9.611	0.630	+3.34	+10.2*
29	8 45 42	33	8 , 6	+1 49.04	− 3 54.7	4 31 37.13	+16 44 43.2	*n*9.550	0.599	+3.38	+10.5*
Dec. 1	8 43 22	33	10 , 6	−0 9.65	− 8 34.2	4 29 38.48	+16 40 3.8	*n*9.537	0.595	+3.42	+10.6*
8	8 37 4	34	8 , 6	+1 27.71	− 6 31.3	4 22 57.47	+16 26 10.2	*n*9.478	0.580	+3.44	+11.0*
9	7 58 2	34	12 , 6	−0 35.31	− 8 5.6	4 22 5.08	+16 24 35.9	*n*9.547	0.603	+3.45	+11.0*

1909 Cin. M. T.	*	Comp.	Δα	Δδ	App. α	App. δ	log pΔ		Red. to App. Pl.	
Halley's Comet.										
h m s			m s	″	h m s	° ′ ″			s	″
Nov. 4 11 16 23	35	8 . 4	+0 16.22	+ 1 58.0	5 45 39.29	+16 51 6.2	n9.583	0.613	+2.76	+ 6.1†
11 10 19 29	37	10 . 6	−1 8.93	−13 42.6	5 30 40.80	+16 45 30.3	n9.602	0.625	+2.95	+ 6.7*
13 10 17 25	38	10 . 6	−1 20.47	−16 29.7	5 25 40.20	+16 43 3.4	n9.588	0.618	+3.02	+ 6.9*
26 14 47 30	39	12 . 6	+0 32.52	−16 48.8	4 44 2.96	+16 11 56.7	9.451	0.575	+3.32	+ 9.6*
Dec. 4 12 29 24	40	0 . 8	....	+ 4 40.2	....	+15 29 22.0	....	0.551	....	+11.5†
4 12 53 49	40	9 . 0	−2 11.41	. . .	4 12 28.75	. .	9.380	...	+3.39	...†
17 7 23 1	41	8 . 6	+1 1.74	− 1 57.3	3 16 28.15	+13 49 3.8	n9.401	0.600	+3.23	+14.5*
Comet 1909 *c*.										
Dec. 9 8 42 51	42	9 . 6	+2 15.39	− 0 0.6	6 17 13.88	+36 21 12.5	n9.712	0.442	+4.11	+ 0.6*

* = J. G. Porter. † = Everett I. Yowell.

Mean Places of Comparison Stars.

*	α	δ	Authority
	1908.0 h m s	1908.0 ° ′ ″	
1	21 54 54.30	+74 5 51.9	Comp. with 2
2	21 57 24.40	+74 6 58.3	O. Arg. 23280
3	21 7 4.11	+71 18 27.0	O. Arg. 21828-9
4	20 42 29.43	+69 2 28.3	Christiania, A.N. 4285
5	20 44 3.14	+68 59 39.1	" "
*6	20 25 23.37	+66 10 22.4	Chris. and 2 Cin. obs.
7	19 37 58.86	+55 3 40.4	Harv. A.G. 6141, Hels. A.G. 10684
8	18 59 31.81	+23 29 29.6	Ber. B. A.G. 6810
	1909.0	1909.0	
†9	13 40 10.62	−17 38 1.1	Bord.4021, Wash.A.G.Z.
10	13 38 23.40	−17 33 12.3	Bord.4013, Wash.A.G.Z.
11	13 32 16.66	−16 51 12.7	Wash. A.G.Z. 2 obs.
12	13 18 29.64	− 9 52 22.9	Wien O. A.G. 4789
13	13 15 41.29	− 9 42 47.9	" 4776
14	13 41 21.16	−13 34 21.1	Mü. 9494. Bonn Sup.
15	13 40 10.91	−13 24 3.1	Mü. 9475. Sant. 1260
16	17 19 21.78	− 8 0 24.5	Wien O. A.G. 5906
17	17 10 51.84	− 8 33 53.2	" 5875
18	17 29 41.68	− 9 54 47.0	" 5933
19	17 23 17.13	− 8 34 55.5	" 5919
20	17 20 52.97	− 8 35 28.9	" 5910
21	1 49 38.13	+33 17 54.7	Leid. A.G. 707
	h m s	° ′ ″	
22	1 50 50.08	+34 33 16.0	Leid. A.G. 718
23	2 0 55.09	+38 27 53.8	Lund. A.G. 979
24	2 13 38.28	+43 14 34.2	Bonn A.G. 1978
25	2 19 33.30	+45 31 3.3	" 2044
26	2 51 50.67	+14 14 33.8	Leip. I. A.G. 876
27	2 47 43.67	+13 43 21.4	" 848
28	2 40 9.91	+12 46 51.0	" 805
29	4 9 37.81	+24 4 53.5	Ber. B. A.G. 1367
30	4 6 22.81	+24 11 46.1	" 1346
31	3 56 39.29	+24 13 53.9	" 1297
32	4 34 6.58	+16 34 29.0	Ber. A. A.G. 1255
33	4 29 44.71	+16 48 27.4	Batterman '95, 243
34	4 21 26.32	+16 32 30.5	Ber. A, A.G. 1178
35	5 45 20.31	+16 49 2.1	Comp. with 36
36	5 46 17.37	+16 45 9.3	Ber. A, A.G. 1730
37	5 31 46.78	+16 59 6.2	Cin$_3$ 1048
38	5 26 57.65	+16 59 26.2	Ber. A, A.G. 1564
39	4 43 27.12	+16 28 35.9	" 1311
40	4 14 36.77	+15 24 30.3	Ber. Jahr.
41	3 15 23.18	+13 50 46.6	Leip. I. A.G. 992
42	6 14 54.38	+36 21 12.5	Lund A.G. 3242

* The Declination of the Christiania observation has been corrected −2′.

† A proper motion in Declination of −0″.15 has been applied.

NOTE ON 162.1907 *PEGASI*,

BY PAUL S. YENDELL.

Mr. Sperra, in *A.N.*, 1356, s. 287, publishes the results of his observations of the star 162. 1907 *Pegasi* = DM + 34°-4597.

I had the star under observation during the last three months of 1909, and though my observations do not afford detailed evidence on the light-curve, they completely confirm the variability and the shortness of the star's period.

Dorchester, 1910 *February* 22.

ON THE LIGHT-VARIATIONS OF u *HERCULIS*,

By PAUL S. YENDELL.

In the early months of the year 1909 my attention was called to the light-changes of the star u *Herculis* upon receiving No. 11 of the *Publications of the Allegheny Observatory*, containing the announcement of the true character of the light-changes of this star.

During the early years of my work upon the Variable Stars, I had paid some attention to this star, and I at once proceeded to examine my records, to ascertain what confirmation, if any, of the spectroscopic results could be drawn from them.

I found available for the purpose about a hundred and eighty observations between the years 1888 and 1907, about three-fourths of the number having been made in the years 1888 and 1889, and nearly all the remainder in the year 1895. All these observations were made on the supposition that the star was of the irregularly periodic type, so that commonly only a single observation was made each night.

In order to obtain independent elements, based on visual observations alone, I proceeded to assemble these observations for the purpose of forming a mean light-curve, using for trial elements, as principal Epoch a day previous to that of my first observation in 1888, with the approximate period $2^{d}.05$.

Upon plotting the single observations for the first two years, each year by itself, on these elements, although the variation was shown to be distinctly of the β *Lyrae* type, it became evident, from the displacement of the minima, that the assumed period was too short, and a longer period was tried in a similar manner; between the values $2^{d}.05$ and $2^{d}.052$, some five or six approximations were made, the elements finally found to give the best results being

$$\text{Min.} = 1888 \text{ July } 11.4812 \text{ Gr. M.T.} + 2^{d}.05064\ E$$

The readings from the mean light-curve are:

$T-t$	Lt.	Mag.	$T-t$	Lt.	Mag.
d			d		
0.00	7.20	5.38	1.03	8.10	5.23
0.10	9.80	4.97	1.10	10.40	4.83
0.20	11.18	4.75	1.20	11.80	4.70
0.30	12.00	4.67	1.30	12.40	4.61
0.40	12.50	4.60	1.40	12.60	4.59
0.50	12.64	4.58	1.50	12.75	4.55
0.55	12.70	4.57	1.60	12.70	4.57
0.60	12.62	4.58	1.70	12.60	4.59
0.70	12.58	4.59	1.80	12.20	4.66
0.80	12.22	4.65	1.90	11.40	4.77
0.90	11.60	4.74	2.00	8.80	5.12
1.00	9.30	4.98	2.05	7.20	5.38

The mean curve drawn from comparison with these elements is of the pure β *Lyrae* type, with a principal minimum of $5^{M}.38$, a maximum of $4^{M}.57$ at $0^{d}.55$, a secondary minimum of $5^{M}.23$ at $1^{d}.03$ and a maximum of $4^{M}.57$ at $1^{d}.60$. All these phases are well-marked, and the curve generally symmetrical.

The comparison-stars and light-scale used were as follows, the magnitudes being those of the *Potsdam Photometrie General Catalogue:*

		M	Lt.
$c = \rho$	*Herculis*	4.33	14.4
$d =$ e	"	4.78	11.3
$b =$ d	"	5.58	5.6
$a =$ w	"	5.68	5.0

The light-range assigned to the star in CHANDLER'S *Third Catalogue* is from $4^{M}.6$ to $5^{M}.4$.

It will be noticed that the secondary minima are much fainter and more sharply defined than those shown in Mr. ICHINOHE'S mean light-curve in his very interesting paper in *A.N.*, 4381. This difference, as my curve is formed from observations made from fifteen to twenty-one years earlier, may have some bearing on the question of Mr. ICHINOHE'S suggested possible progressive changes in the star's light-curve.

From the observations assembled, twenty-seven principal minima were deduced by the application of the mean light-curve. The great majority of these dates were indicated by a single observation each, as was unavoidable from the nature of the case, and therefore leave something to desire in the matter of precision; the probable error of a single determination of principal minimum is found to be $\pm 0^{d}.021$. To save room, I have condensed each year's minima in a single normal date except for 1895-1902, which having two minima each have been joined in a single normal. These dates, with the mean of the residuals of each group, are given below:

Season	E	O — C	w	*p.e.*
		d		d
1888	30	−0.011	6	±0.009
1889	198	+0.009	17	0.005
1895–1902	1839	+0.020	4	0.010
1909	3711	−0.022	6	±0.009

w signifies the number of minima forming each normal.

An inspection of the above table is instructive. It is at once obvious that what I may, for shortness, call the accepted period $2^{d}.0512$, does not satisfy my three groups of observations which extend over the fourteen years from 1888 to 1902. For the 1895-1902 group, using my principal minimum and the accepted period, the residual is $-0^{d}.858$.

During the months from April to the end of June, 1909, I made a short series of observations for the purpose of continuing this comparison, there being thirty-one observations in all. From these I deduce six minima, the normal date formed from which gives a residual of $-0^d.022$ as compared with my elements; the residual shown by the use of the accepted period combined with my own principal Epoch is $-2^d.056$, more than an entire period. There is no question here of an error in the numeration of the Epochs, as these have been carefully examined for that very chance of error, and checked. It is plain that a period of $2^d.0512$, starting with a date near the beginning of that year's observations as principal Epoch, would satisfy that season's observations within the limits of a reasonable error; but for a term of fifteen or twenty years it is obviously too long.

Dorchester, Mass., 1910 *February* 19.

OBSERVATIONS OF COMET *e* 1909 (*DANIEL*) AND OF COMET *a* 1910.

BY E. E. BARNARD.

	*C.S.T.	$\Delta\alpha$	$\Delta\delta$	Comp.	α App.	δ App.	Red. to App.		*
				COMET *e* 1909 (DANIEL)					
1909	h m s	m s	′ ″		h m s	° ′ ″	s	″	
Dec. 7	9 51 9	+0 0.39	+1 34.7	4 , 6	6 16 42.11	+34 44 22.0	+4.00	+ 0.5	1
19	11 40 25	−0 2.50	+0 24.5	4 , 7	6 18 5.99	+44 6 57.4	+4.75	+ 0.8	2
				COMET *a* 1910					
1910									
Feb. 7	6 25 50	+0 27.0	+1 15±	5 . 0	21 49 53.1	+6 27.4±	−1.83	−10.7	3

* Central Standard Time, 6 hours slow of Greenwich Mean Time.

Mean Places of the Comparison-Stars for the Beginning of the Year.

*	α	δ	Authority	*	α	δ	Authority
	h m s	° ′ ″			h m s	° ′ ″	
1	6 16 37.72	+34 42 46.8	Leiden, A.G. 2575	3	21 49 27.98	+ 6 26 22.5	Leipzig. A.G. 11000
2	6 18 3.74	+44 6 32.1	9M.8 comp. with Bonn A.G. 5184				

Comparisons of star 2 with Bonn A.G. 5184, on Dec. 28, 1909, give: $\Delta\alpha$ $+2^m\ 39^s.48$ (6) ; $\Delta\delta$ $+0'\ 30''.0$ (3)

Measured $\Delta\alpha$ (Comet − Star)

1909	Dec.	7	+ 1″.81
		19	26″.95

1909 *Dec.* 7. Comet *e* 1909, 11 mag. Much brighter in the middle and seems to be very large. There is probably a faint diffusion preceding.

Dec. 19. Comet *e* 1909, 12 mag. Much brighter in the middle. 2′ diameter. Very diffused.

The position of Comet *a* 1910 was obtained with the 5-inch guiding telescope of the BRUCE photographic doublet. One of the guiding wires was set perpendicular to sidereal motion and transits were observed with a stop watch (afterwards tested and found to be accurate). The $\Delta\delta$ was obtained by estimation in terms of the $\Delta\alpha$, and may be 5″ to 10″ in error, though this is not probable.

Unfortunately cloudy weather here prevented photographs being taken of this splendid comet during the phases of its greatest brightness, except on Jan. 21 and 24 when fair negatives were obtained. A photograph on Feb. 3 shows a nebulous extension beyond the head towards the Sun about 12′ long. It lies in the prolongation of the south edge of the tail and is shown on all three photographs of that night.

Yerkes Observatory, 1910 *February* 11.

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MICROMETRIC MEASURES OF DOUBLE STARS,

By PHILIP FOX.

The following measures of miscellaneous double stars have been made with the 12-inch and 40-inch refractors of the Yerkes Observatory and the 18½-inch refractor of the Dearborn Observatory. A displaced diaphragm in the tube of the 12-inch telescope indavertently reduced the aperture to 10 inches. This remark applies also to my earlier measures. A.N., 4336. Each position-angle is the mean of four settings, each distance the mean of three or more double distances. The telescope used for each measure is indicated by its aperture.

The numbers in bold-face type are taken from Burnham's General Catalogue. β G.C.

β **G.C. 22.** Es. 113.

	°	″	
1909.747	122.8	6.94	18½
9.758	124.4	6.93	18½
9.763	123.4	7.17	18½
1909.756	123.5	7.01	

This star is BD 66°8 BD 66°6, however, is double.

28. H. 1001.

1909.744	77.0	15.72	18½
9.747	75.8	15.58	18½
9.758	76.1	15.48	18½
1909.750	76.3	15.59	

29. Es. 114.

A and B.

1909.747	161.7	4.24	18½
9.758	163.1	4.51	18½
9.763	163.9	4.45	18½
1909.756	162.9	4.40	

A and C.

1909.758	18.7	110.31	18½
9.865	19.2	109.70	18½
9.909	18.6	109.95	18½
1909.844	18.8	109.99	

C = 8ᴹ.9..

32. O. Stone 1.

1909.763	108.1	9.94	18½
9.818	107.9	9.57	18½
9.835	108.0	9.87	18½
1909.805	108.0	9.79	

β **G.C. 44.** Hu. 503.

A and B.

	°	″	
1909.758	30.5	4.57	18½
9.763	31.9	4.21	18½
9.766	32.5	4.01	18½
1909.762	31.6	4.26	

A and C.

1909.758	55.9	40.91	18½
9.766	56.3	40.97	18½
1909.762	56.1	40.94	

C = 11ᴹ.2.

52. β 254.

1909.865	238.9	7.33	18½
9.909	236.6	7.00	18½
9.967	234.1	7.52	18½
9.994	233.5	7.49	18½
1909.934	235.8	7.33	

114. Weisse 1.

1909.597	104.2	5.47	40
9.636	106.2	5.45	40
9.655	104.8	5.33	40
1909.629	105.1	5.42	

W² 0ʰ 264.

137. Kr. 4.

1909.826	186.7	2.34	18½
9.865	186.7	2.29	18½
9.900	186.7	2.27	18½
1909.864	186.7	2.30	

Shows motion.

β **G.C. 147.** H. 1955.

A and B.

	°	″	
1909.711	29.5	49.98	18½
9.717	30.4	. . . .	18½
9.758	29.5	50.86	18½
9.838	28.8	50.46	18½
1909.756	29.5	50.43	

B = 12ᴹ.5.

A and C.

1909.758	9.6	60.96	18½
9.838	8.5	60.90	18½
1909.798	9.0	60.93	

C = 13ᴹ.0.

197. OΣ 9.

1909.717	52.7	1.68	18½
9.736	49.2	2.11	18½
9.747	49.9	1.99	18½
1909.733	50.6	1.93	

220. O. Stone 2.

1909.597	273.7	6.02	40
9.725	272.8	6.22	18½
9.838	273.0	6.05	18½
1909.720	273.2	6.10	

246 = 269. Es. 2.

1909.717	112.7	6.01	18½
9.736	113.1	5.88	18½
9.739	113.2	5.77	18½
1909.731	113.0	5.89	

Distance somewhat less than in the original measures.

β G.C. 271. β 780.

		″	
1909.597	136.4	2.77	40
9.636	136.4	2.64	40
9.655	136.8	2.58	40
1909.629	136.5	2.66	

The angle is decreasing.

297 = 326. Es. 3.

1909.717	156.5	8.18	18½
9.736	156.6	8.13	18½
9.739	157.4	8.28	18½
1909.731	156.8	8.20	

Distance less than in the orginal measures.

338. Hd. 30.

1909.763	39.7	6.56	18½
9.835	38.7	6.57	18½
9.838	39.9	7.06	18½
1909.812	39.4	6.73	

349. OΣ 16.

1909.709	24.1	13.85	18½
9.736	21.0	13.96	18½
9.739	24.0	13.93	18½
9.758	22.1	14.13	18½
1909.735	22.8	13.97	

392. Σ 55.

1909.597	323.8	2.24	40
9.636	323.5	2.10	40
9.655	324.3	2.23	40
1909.629	323.9	2.19	

413. Müller 3.

1909.578	192.9	3.05	40
9.758	192.1	2.94	18½
1909.668	192.5	2.99	

426. Σ 60. η *Cassiopeiae.*

1909.739	238.6	6.13	18½
9.742	241.6	6.43	18½
9.744	240.6	6.29	18½
9.747	240.8	6.17	18½
1909.743	240.4	6.25	

433. H. 1054.

A and B.

1909.739	180.9	8.95	18½
9.742	178.2	8.77	18½
9.744	181.8	8.86	18½
9.747	178.5	8.90	18½
1909.743	179.9	8.87	

B = 11ᴹ.3.

β G.C. 433. A. 1054.

A and C.

	°	″	
1909.739	62.3	93.00	18½
9.742	62.0	93.11	18½
9.744	62.0	.	18½
9.747	61.8	92.82	18½
1909.743	62.0	92.98	

C = 10ᴹ.0.

C and D.

1909.739	236.3	25.85	18½
9.742	236.6	25.54	18½
9.747	236.6	25.79	18½
1909.743	236.5	25.73	

D = 11ᴹ.4.

446. Ho. 4.

1909.597	21.7	1.85	40
9.636	20.7	1.89	40
9.655	19.6	1.78	40
1909.629	20.7	1.84	

455. β 1.

A and B.

1909.739	75.6	1.44	18½
9.747	79.3	1.45	18½
9.865	78.7	1.37	18½
9.909	79.7	1.50	18½
1909.815	78.3	1.44	

A and C.

1909.739	132.3	4.07	18½
9.747	130.9	3.77	18½
9.824	132.4	4.30	18½
9.909	130.7	4.02	18½
1909.805	131.6	4.04	

A and D.

1909.739	192.7	8.84	18½
9.747	192.8	9.01	18½
9.824	193.0	9.14	18½
9.909	193.3	9.08	18½
1909.805	192.9	9.02	

456. Σ 67.

1909.597	359.3	2.11	40
9.973	359.8	2.09	18½
1909.785	359.5	2.10	

The angle is decreasing.

460. A.G. S.

1909.739	33.8	17.78	18½
9.747	34.6	17.56	18½
9.758	33.9	17.61	18½
1909.748	34.1	17.65	

A.G. Chris. 460.

β G.C. 474. Σ 69.

	°	″	
1909.845	15.4	24.20	18½
9.856	15.8	23.62	18½
9.900	..	23.97	18½
9.967	14.7	23.76	18½
1909.892	15.3	23.89	

486. H. 629.

A and B.

1909.597	69.7	11.07	40
9.636	70.4	10.86	40
9.666	70.2	10.60	40
9.725	70.2	10.73	18½
1909.656	70.1	10.81	

A = 8ᴹ.6. B = 11ᴹ.0.

A and C.

1909.636	254.6	70.69	40
9.725	254.8	70.73	18½
1909.680	254.7	70.71	

C = 8ᴹ.3.

499. Σ 76.

1909.636	197.5	3.05	40
9.973	194.7	3.18	18½
1909.804	196.1	3.11	

556. Σ 85 rej.

A and B.

1909.597	158.7	29.16	40
9.636	158.9	29.29	40
9.725	158.7	29.25	18½
1909.653	158.8	29.23	

A and C.

1909.597	117.4	....	40
9.636	117.4	34.32	40
9.725	117.2	34.27	18½
1909.653	117.3	34.29	

560. Σ 86.

1909.578	152.8	13.73	40
9.636	152.6	13.70	40
9.725	153.1	13.61	18½
1909.646	152.8	13.68	

618. H. 2023.

1909.636	30.7	4.38	40
9.975	29.9	3.99	18½
1909.805	30.3	4.18	

620. Σ 94.

1909.666	95.9	19.81	12
9.725	95.6	19.72	18½
9.742	96.1	19.89	18½
1909.711	95.9	19.81	

β G.C. **636.** H. 2025.

A and B.

	°	″	
1909.824	56.8	11.65	18½
9.826	59.0	11.58	18½
9.845	57.3	11.62	18½
1909.832	57.7	11.62	

A = 9ᴹ.8. B = 9ᴹ.8.

A and C.

1909.824	316.5	78.59	18½
9.826	316.3	78.47	18½
9.845	316.5	78.24	18½
1909.832	316.4	78.43	

C = 9ᴹ.5.

649. H. 2028.

1909.900	203.4	61.30	18½
9.958	203.4	61.07	18½
9.967	204.2	61.13	18½
1909.942	203.7	61.17	

660. Howe 2.

1909.758	141.0	14.93	18½
9.867	139.3	14.91	18½
9.975	141.3	14.84	18½
1909.867	140.5	14.89	

677. Hd. 45.

1909.758	99.9	36.76	18½
9.763	99.8	37.23	18½
9.838	100.2	36.88	18½
1909.786	100.0	36.96	

681. Howe 3.

1909.742	285.4	7.79	18½
9.758	287.6	7.84	18½
9.867	287.0	8.10	18½
1909.789	286.7	7.91	

694 = 686. Hd. 48.

1909.867	60.8	9.75	18½
9.975	60.5	9.57	18½
9.991	60.8	10.09	18½
1909.944	60.7	9.80	

811. Howe 5.

1909.867	30.5	13.37	18½
9.975	30.5	13.13	18½
1909.921	30.5	13.25	

1156. H. 2118.

1909.845	46.4	29.86	18½
9.865	47.3	29.84	18½
9.958	46.4	29.80	18½
1909.889	46.7	29.83	

β G.C. **1186.** Tucker.

	°	″	
1909.865	237.8	2.76	18½
9.900	237.3	3.00	18½
9.917	236.6	3.18	18½
1909.894	237.2	2.98	

BD 37°518.

1192. H. 2122.

1909.845	317.8	31.64	18½
9.865	318.3	31.70	18½
9.958	316.8	31.52	18½
1909.889	317.6	31.62	

I reverse the angle.

1193. OΣ (App.) 26.

A and B.

1909.824	20.2	63.51	18½
9.845	19.9	63.23	18½
9.865	19.7	63.07	18½
9.958	19.5	. . .	18½
1909.873	19.8	63.27	

A and C.

1909.824	81.8	75.24	18½
9.917	81.5	74.69	18½
9.958	80.8	74.69	18½
1909.900	81.4	74.87	

C = 11ᴹ.2.

1568. OΣ 50.

1909.845	195.4	1.37	18½
9.967	197.2	1.56	18½
9.994	196.1	1.48	18½
1909.935	196.2	1.47	

1586. H. 1132.

1909.845	20.9	7.39	18½
9.865	20.4	7.51	18½
9.900	22.4	7.35	18½
1909.870	21.2	7.42	

1645. H. 2179.

1909.845	342.7	26.03	18½
9.900	341.7	. . . .	18½
9.958	342.7	26.10	18½
1909.901	342.4	26.06	

2036. H. 1141.

1909.845	343.4	13.76	18½
9.958	343.6	14.01	18½
9.967	344.8	13.74	18½
1909.923	343.9	13.84	

BD 68°308.

Star 13ᴹ.0 about 20″ preceding.

β G.C. **2041.** Σ 3114.

	°	″	
1909.865	168.8	2.67	18½
9.867	168.6	2.40	18½
9.898	167.4	2.63	18½
1909.877	168.3	2.57	

2060. Σ 498.

1909.845	165.0	1.19	18½
9.898	164.0	1.34	18½
9.909	167.6	1.13	18½
1909.884	165.5	1.22	

2061. Σ 500.

1909.845	80.4	4.05	18½
9.867	76.6	4.11	18½
9.898	77.3	4.14	18½
9.967	.	3.92	18½
9.991	77.0	. . .	18½
1909.914	77.8	4.05	

Es. 574.

A and B.

1909.971	252.5	0.92	12
9.845	253.0	1.07	18½
9.898	249.9	0.99	18½
1909.571	251.8	0.99	

BD 47°1122.

A and C.

1908.241	242.0	34.41	12
8.255	242.8	34.28	12
8.277	243.1	34.34	12
8.282	243.5	34.57	12
1908.264	242.8	34.40	

3190. Σ 859.

1909.917	. . .	37.19	18½
9.953	246.1	37.54	18½
9.958	244.8	. .	18½
9.967	244.9	37.16	18½
1909.949	245.3	37.30	

3522. Howe 14.

1909.173	32.3	8.89	12
9.911	32.5	8.93	18½
9.994	32.0	9.16	18½
1909.693	32.3	8.99	

3596. A.G. Clark 1. *Sirius.*

1909.162	93.4	8.79	12
9.173	95.4	8.55	12
1909.167	94.4	8.67	

3858. Σ 1025.

1909.826	135.2	24.22	18½
9.845	135.4	24.37	18½
9.865	134.2	24.52	18½
1909.845	134.9	24.37	

β **G.C. 4538.** β 102.

	°	″	
1909.911	119.9	3.28	18½
9.953	120.6	3.24	18½
9.958	121.8	3.22	18½
1909.941	120.8	3.25	

4656. Σ 1235.

1909.845	78.0	1.19	18½
9.898	78.2	1.32	18½
9.909	81.0	1.31	18½
1909.884	79.1	1.27	

5007. H. 4193.

1908.277	119.8	3.34	12
9.953	118.2	3.09	18½
9.958	117.1	2.97	18½
9.967	118.1	3.38	18½
1909.539	118.3	3.19	

$8^{M}.0$ and $8^{M}.5$.

5163. H. 4224.

1909.173	116.1	7.55	12
9.953	116.3	7.97	18½
9.958	116.0	7.97	18½
1909.695	116.1	7.83	

5168. Σ 1373.

1908.277	127.3	2.00	12
9.337	127.1	1.90	12
9.340	127.9	2.07	12
1908.985	127.4	1.99	

5334. β 911.

1909.173	307.5	4.66	12
9.953	307.8	4.61	18½
9.958	308.8	4.48	18½
1909.695	308.0	4.58	

5351. LEWIS 10.

1909.044	5.7	1.55	40
9.337	4.2	1.33	12
9.898	7.3	1.44	18½
9.909	8.4	1.47	18½
1909.547	6.3	1.45	

$9^{M}.3$ and $9^{M}.6$.

5695. OΣ 231 rej.

A and B.

1909.309	264.1	35.43	40
9.312	264.2	35.52	40
9.337	263.9	35.59	12
1909.319	264.1	35.51	

A and C.

1909.309	336.4	163.03	40
9.312	336.3	163.58	40
9.337	336.2	163.42	12
1909.319	336.3	163.34	

β **G.C. 5695.** OΣ 231 rej.

C and c.

	°	″	
1909.309	34.45	134.64	40
9.312	34.65	134.78	40
1909.310	35.55	134.71	

5724. SH. 372.

1909.173	299.9	19.22	12
9.309	299.2	19.29	40
9.312	300.0	19.19	40
1909.265	299.7	19.23	

5835. A.G. 175.

1909.060	182.9	2.16	40
9.173	183.3	2.13	12
9.958	182.6	2.33	18½
1909.397	182.9	2.21	

A.G. Alb. 4308.

6160. A.G. 177.

A and B.

1909.312	219.1	7.72	40
9.337	218.0	7.39	12
9.340	217.7	7.67	12
9.425	218.4	7.82	40
1909.354	218.3	7.65	

Distance is increasing. $9^{M}.0$-$10^{M}.0$.

A and C.

1909.312	53.4	97.33	40
9.425	53.5	96.99	40
1909.368	53.4	97.16	

C = $11^{M}.2$.

6560. Σ 1764.

1909.271	30.6	16.17	40
9.312	30.9	16.02	40
9.331	31.2	15.93	40
1909.305	30.9	16.04	

6563. Σ 1765 rej.

1909.271	163.2	39.43	40
9.312	163.5	39.12	40
9.331	163.4	39.21	40
1909.305	163.4	39.25	

A of **6560** and A of **6563.**

1909.312	138.8	172.01	40
9.331	138.7	172.41	40
1909.321	138.8	172.21	

6611. Wx. 5.

1909.271	160.2	1.06	40
9.312	159.9	1.12	40
9.331	159.5	1.05	40
1909.305	159.9	1.08	

Lal. 25358

β **G.C. 6724.** OΣ 274.

	°	″	
1909.173	63.7	13.67	12
9.312	65.1	13.81	40
9.340	65.3	13.51	12
1909.275	64.7	13.66	

Distance decreasing.

6732. OΣ 275.

1909.271	351.6	5.03	40
9.312	352.0	5.15	40
9.406	352.3	4.95	40
9.425	350.9	5.04	40
1909.354	351.7	5.04	

6762. Σ 1813.

1909.406	190.8	4.96	40
9.425	191.4	4.92	40
9.515	191.4	4.99	12
1909.449	191.2	4.96	

6784. H. 1248.

1909.312	162.7	7.72	40
9.425	161.6	7.72	40
1909.368	162.1	7.72	

6785. Σ 1824.

1909.515	281.1	5.14	12
9.518	280.6	5.24	12
1909.516	280.8	5.19	

6837. Σ 1833.

1909.406	167.7	5.54	40
9.425	166.8	5.71	40
9.515	168.2	5.47	12
1909.449	167.6	5.57	

7161. H. C. WILSON 13.

1909.406	288.4	5.08	40
9.502	287.0	4.97	40
9.515	286.5	4.83	12
1909.474	287.3	4.96	

SD 4°3838.

7202. OΣ (App.) 137.

1907.271	105.5	73.61	40
9.312	105.6	73.59	40
9.340	105.6	73.59	12
1909.308	105.6	73.60	

7212. Σ 1934.

A and B.

1909.271	25.7	7.11	40
9.312	27.4	7.07	40
9.340	25.9	7.25	12
1909.308	26.3	7.14	

β **G.C. 7212.** Σ 1934.

A and C.

	°	″	
1909.312	217.7	141.13	40
9.340	217.5	141.38	12
1909.326	217.6	141.25	

C = 9^{M}.

7237. Σ 3093.

1909.406	142.0	28.62	40
9.502	142.3	28.61	40
9.515	142.0	28.60	12
1909.474	142.1	28.61	

7282. Hu. 150.

1909.406	24.0	4.45	40
9.518	23.7	4.63	12
1909.462	23.8	4.54	

7317. Σ 1956.

1909.271	35.0	1.81	40
9.312	40.1	1.88	40
9.367	41.9	1.85	40
1909.317	39.0	1.85	

7869. OΣ (App.) 151.

A and B.

1909.271	172.5	80.27	40
9.406	172.7	80.55	40
9.425	172.6	80.55	40
9.502	172.5	80.51	40
1909.401	172.6	80.47	

Distance increasing.

B and C.

1909.271	357.6	18.47	40
9.406	359.3	18.41	40
9.502	359.0	18.33	40
1909.393	358.6	18.40	

7874. H. 4923.

1909.312	160.0	9.49	40
9.331	160.0	9.42	40
9.502	159.7	9.56	40
1909.382	159.9	9.49	

Angle decreasing, distance increasing.

7940. OΣ 326.

1909.406	211.8	16.09	40
9.502	211.9	16.03	40.
9.520	....	16.02	40
1909.476	211.8	16.05	

Change very doubtful.

β **G.C. 8015.** Σ 2167 rej.

	°	″	
1909.367	221.3	18.48	40
9.520	220.9	18.63	40
9.766	220.5	18.48	18½
1909.551	220.9	18.53	

BD 49°2629.

Roe. 1.

1908.876	187.0	22.09	12
9.766	187.5	22.32	18½
1909.321	187.2	22.20	

BD 41°2968. $6^{\mathrm{M}}.3$ and $11^{\mathrm{M}}.5$.

9034. H. 2854.

1909.312	50.6	8.07	40
9.331	50.7	8.14	40
9.367	51.2	8.00	40
1909.337	50.8	8.07	

Angle perhaps decreasing.

C and D.

1909.331	212.2	11.56	40
9.367	209.2	11.76	40
1909.349	210.7	11.66	

C = $13^{\mathrm{M}}.2$. D = $14^{\mathrm{M}}.0$. In field with **9034.**

9085. Σ 2471.

1909.312	124.0	8.40	40
9.540	...	8.35	40
9.559	123.0	8.23	40
9.736	122.2	8.34	18½
1909.537	123.1	8.33	

9124. Σ 2482.

1909.559	343.1	1.93	40
9.570	342.9	1.78	12
9.973	343.5	2.14	18½
1909.701	343.2	1.95	

9136. Σ 2484.

1909.616	227.5	2.49	40
9.973	224.2	2.69	18½
9.975	223.9	2.85	18½
1909.855	225.2	2.68	

9204. Σ 2494 rej.

1909.540	81.1	25.95	40
9.559	81.4	25.65	40
9.570	81.8	25.59	12
1909.556	81.4	25.73	

9279. Σ 2513.

1909.540	318.3	2.22	40
9.559	317.2	2.28	40
9.570	317.5	1.94	12
1909.556	317.7	2.15	

β **G.C. 9304.** H. 1395.

A and B.

	°	″	
1909.367	63.9	2.96	40
9.425	64.3	2.71	40
9.540	62.2	2.96	10
1909.444	63.5	2.88	

A and C.

1909.367	14.2	55.93	40
9.425	14.3	56.02	40
9.540	14.1	56.08	40
1909.444	14.2	56.01	

C = $10^{\mathrm{M}}.3$

9317. *β* 1286.

A and B.

1908.838	100.3	6.33	12
9.331	101.7	6.28	40
9.367	100.4	6.49	40
1909.179	100.8	6.37	

10220. Ho. 130.

1908.799	283.7	2.09	40
9.973	281.6	2.06	18½
9.975	283.3	2.06	18½
1909.582	282.9	2.07	

11120. Es. 34.

A and B.

1909.616	134.7	2.75	40
9.739	135.0	..	18½
9.742	134.7	2.69	18½
1909.699	134.8	2.72	

Angle perhaps decreasing.

A and C.

1909.616	69.8	39.68	40
9.739	69.6	39.83	18½
9.742	69.7	39.67	18½
1909.699	69.7	39.73	

11152. Ho. 464.

1908.785	105.6	18.03	12
9.975	107.1	17.99	18½
1909.380	106.3	18.01	

Angle and distance both increasing.

11217. *β* 374.

1909.711	142.4	1.93	18½
9.967	141.3	1.71	18½
9.973	135.9	1.75	18½
1909.884	139.9	1.80	

β **G.C. 12225.** Σ 2989.			
	°	″	
1909.818	138.2	1.56	18½
9.867	140.4	1.59	18½
9.967	140.2	1.46	18½
1909.884	139.6	1.54	

β **G.C. 12495.** Es. 149 A and B.			
	°	″	
1909.742	120.2	5.73	18½
9.967	117.1	5.58	18½
9.973	118.6	5.80	18½
1909.894	118.6	5.70	

β **G.C. 12495.** Es. 149. A and C.			
	°	″	
1909.967	177.7	50.66	18½
9.973	176.6	50.46	18½
1909.970	177.1	50.56	

C = 11ᴹ.0.

Dearborn Observatory, Northwestern University, 1910 *Feb.* 10.

OBSERVATIONS OF COMET *c* 1908 (*MOREHOUSE*),

MADE AT THE CHAMBERLIN OBSERVATORY, UNIVERSITY PARK, COLO.,

By HERBERT A. HOWE.

The following observations were made with the Bruce filar micrometer on the twenty-inch equatorial. They were reduced and prepared for publication by Miss Myrtle L. Richmond, of the University of Denver.

1908 Denver. M.T.		Δα	Δδ	Comp.	App. α	log. pΔ	App. δ	log pΔ	Red. to App.		⋆
	h m s	m s	′ ″		h m s		° ′ ″		s	″	
Oct. 30	9 13 35	−1 58.75	− 5 45.9	19 , 6	18 59 6.70	9.677	+24 41 9.8	0.627	+0.55	+15.3	1
30	9 22 58	−3 27.13	+ 9 32.4	10 , 3	18 59 6.47	9.682	24 40 30.0	0.638	+0.56	+15.3	2
Nov. 3	7 11 33	−0 40.92	+ 0 56.7	20 , 8	18 56 13.58	9.543	19 14 5.9	0.574	+0.56	+13.2	3
3	7 24 43	−0 51.29	+ 2 26.1	20 , 8	18 56 13.35	9.565	19 13 23.7	0.584	+0.56	+13.2	4
4	7 25 8	−0 43.51	+ 1 42.5	20 , 8	18 55 38.03	9.569	17 54 59.5	0.604	+0.56	+12.7	5
4	7 39 40	−2 46.75	+ 2 0.6	19 , 6	18 55 37.57	9.590	17 54 13.6	0.615	+0.57	+12.8	6
6	7 7 49	−2 23.36	− 8 11.4	20 , 6	18 54 36.93	9.550	15 25 13.4	0.624	+0.56	+11.9	7
6	7 20 27	−2 38.46	− 8 24.4	19 , 6	18 54 35.92	9.570	15 24 42.9	0.632	+0.56	+12.0	8
7	7 50 22	+0 55.46	− 6 12.6	20 , 6	18 54 8.22	9.610	14 10 53.0	0.664	+0.55	+11.3	9
7	8 2 45	+2 35.82	− 1 52.1	20 . 6	18 54 8.13	9.623	14 10 16.9	0.672	+0.54	+11.4	10
13	6 57 1	−2 25.26	+ 2 29.5	20 . 6	18 52 10.78	9.567	7 38 59.4	0.700	+0.60	+ 9.1	11
13	7 10 14	−4 15.17	+ 0 48.8	20 , 6	18 52 10.63	9.584	7 38 25.9	0.704	+0.61	+ 9.2	12
14	6 42 38	−0 53.33	+ 5 2.4	20 , 6	18 51 57.11	9.551	6 39 50.4	0.704	+0.60	+ 8.7	13
14	6 52 25	−1 41.75	− 3 31.5	20 , 6	18 51 57.09	9.566	6 39 29.5	0.707	+0.60	+ 8.7	14
16	6 56 47	−0 47.50	+10 41.0	20 , 8	18 51 33.00	9.581	4 44 37.1	0.722	+0.60	+ 7.8	15
16	7 10 32	−5 46.55	+ 1 44.3	20 , 6	18 51 32.98	9.597	4 44 7.9	0.724	+0.62	+ 8.1	16
17	7 10 15	−1 47.44	+ 9 42.1	20 , 6	18 51 23.02	9.600	3 49 2.4	0.729	+0.60	+ 7.5	17
17	7 20 39	+0 16.66	− 4 9.5	20 , 8	18 51 23.05	9.610	3 48 37.1	0.731	+0.59	+ 7.5	18
18	6 49 7	+0 27.39	− 3 51.1	19 , 8	18 51 14.33	9.580	2 56 10.2	0.732	+0.59	+ 7.1	19
18	7 4 6	+1 35.47	+ 3 55.0	20 , 6	18 51 14.24	9.597	2 55 39.8	0.734	+0.58	+ 7.0	20
19	5 46 38	−0 59.05	+ 0 46.4	20 , 6	18 51 6.65	9.486	2 6 9.2	0.733	+0.59	+ 6.9	21
19	5 55 30	−1 1.20	+ 6 16.8	20 , 6	18 51 6.61	9.503	2 5 48.4	0.733	+0.59	+ 6.8	22
20	5 44 51	−1 25.77	− 7 39.5	20 , 6	18 50 59.40	9.490	1 15 13.2	0.739	+0.59	+ 6.6	23
20	5 52 58	−1 27.07	− 7 10.7	20 , 6	18 50 59.32	9.506	+ 1 14 55.6	0.739	+0.59	+ 6.6	24
23	5 32 0	+1 0.94	− 0 27.7	20 , 6	18 50 42.66	9.488	− 1 10 10.0	0.755	+0.59	+ 5.7	25
23	5 45 6	+3 19.33	− 1 27.8	20 , 6	18 50 42.77	9.514	1 10 33.8	0.755	+0.58	+ 5.6	26
26	5 41 1	+4 14.71	− 4 13.2	20 , 6	18 50 31.35	9.528	3 26 11.2	0.767	+0.61	+ 4.8	27
26	5 53 26	+3 58.37	− 1 9.9	20 , 6	18 50 31.25	9.548	3 26 39.1	0.766	+0.61	+ 4.9	28
30	5 50 12	+1 10.75	− 0 11.3	20 , 6	18 50 22.01	9.570	6 11 10.8	0.777	+0.64	+ 3.9	29
30	5 58 39	−1 6.97	− 4 25.5	20 , 6	18 50 21.57	9.579	6 14 25.7	0.776	+0.65	+ 4.0	30
Dec. 4	5 52 54	+1 55.99	− 1 43.6	20 , 6	18 50 16.23	9.594	8 19 6.7	0.782	+0.65	+ 3.1	31
4	6 2 20	+1 17.63	− 8 9.8	20 , 6	18 50 16.30	9.604	8 19 16.4	0.780	+0.64	+ 3.1	32
10	5 44 17	−3 10.48	+ 7 26.4	20 , 6	18 50 11.02	9.615	12 22 1.1	0.787	+0.72	+ 2.1	33
10	5 58 14	3 41.36	+20 20.6	20 , 6	18 50 11.01	9.627	12 22 22.8	0.781	+0.72	+ 2.1	34
11	5 40 16	−2 26.92	− 0 27.6	20 , 6	18 50 10.24	9.616	12 55 41.2	0.788	+0.73	+ 2.2	35
11	5 51 52	−4 4.09	+ 1 59.8	20 , 6	18 50 10.25	9.626	−12 55 54.5	0.783	+0.73	+ 2.3	36

Mean Places of Comparison-Stars for 1908.0.

*	α	δ	Authority
	h m s	° ′ ″	
1	19 1 4.90	+24 46 40.4	A.G. Berlin (B), 6832
2	19 2 33.04	24 30 42.3	" " " 6843
3	18 56 53.94	19 12 56.0	" " (A), 7158
4	18 57 4.08	19 10 44.4	" " " 7162
5	18 56 20.98	17 53 4.3	" " " 7147
6	18 58 23.75	17 52 0.2	" " " 7178
7	18 56 59.73	15 33 12.9	" " " 7159
8	18 57 13.82	15 32 55.3	" " " 7167
9	18 53 12.21	14 16 54.3	A.G. Leipzig I, 6933
10	18 51 31.77	14 11 57.6	" " I, 6923
11	18 54 35.44	7 36 20.8	" " II, 8941
12	18 56 25.19	7 37 27.9	" " II, 8959
13	18 52 49.84	6 34 39.3	" " II, 8921
14	18 53 38.24	6 42 52.3	" " II, 8929
15	18 52 19.90	4 33 48.3	A.G. Albany 6438
16	18 57 18.91	4 42 15.5	" " 6484
17	18 53 9.86	3 39 12.8	" " 6447
18	18 51 5.80	+3 52 39.1	" " 6422
19	18 50 46.35	+ 2 59 54.2	A.G. Albany 6420
20	18 49 38.19	2 51 37.8	" " 6412
21	18 52 5.11	2 5 15.9	" " 6434
22	18 52 7.22	1 59 24.8	" " 6435
23	18 52 24.58	1 22 46.1	" " 6439
24	18 52 25.90	+ 1 21 59.7	" " 6440
25	18 49 41.13	− 1 9 48.0	A.G. Nicolajew 4717
26	18 46 52.86	1 9 11.6	" " 4704
27	18 46 16.03	3 22 2.8	A.G. Strassburg 6338
28	18 46 32.27	3 25 34.1	" " 6339
29	18 49 10.62	6 13 33.4	A.G. W. O. 6426
30	18 51 27.89	6 10 4.2	" " 6459
31	18 48 19.59	8 47 26.2	" " 6418
32	18 48 28.03	8 41 9.7	" " 6421
33	18 53 20.78	12 29 30.2	Munich I 18161
34	18 53 51.65	12 42 45.8	Gould G.C. 25962
35	18 52 36.43	12 55 15.8	Munich 1 18118
36	18 54 13.61	−12 57 56.6	Gould G.C. 25971

NEW DOUBLE STARS,

By E. D. Roe, Jr.

The following new double stars have been found and measured with the 6½-in. Clark refractor and Gaertner micrometer, described in *A.N.* No. 4338. The same notation is used which was introduced in *A.N.* No. 4338, and again employed in *A.N.* No. 4381, where a list of sixteen new pairs found by the writer is given. As in the previous list the positions are for 1910 (using *Durchmusterung* positions corrected for precession).

ρ 17 BD +59°1853.

$17^h\ 50^m\ 8^s$. +59° 39′ (9^M, $9^M.5$).

Found 30 May, 1907.

	°	″
1909.850	56.2	8.19
.860	56.3	8.35
.865	56.2	8.71
1909.858	56.2	8.42

ρ 18 BD +42°3002.

$18^h\ 3^m\ 31^s$ +42° 12′ (9^M, 11^M).

Found 11 September, 1907.

1909.870	171.4	15.62
.875	170.8	16.25
1909.872	171.1	15.93

ρ 19 $19^h\ 31^m\ 53^s$ +35° 11′ (10^M, 10^M).

4′.8 north and $33^s.4$ following β G.C.9435.

Found 23 May, 1907.

1909.860	158.6	8.17
.865	157.5	
.870	155.0	8.64
1909.865	157.0	8.40

ρ 20 $19^h\ 49^m\ 18^s$ +36° 10′ ($9^M.5$, $9^M.5$).

2′.2 south and $19^s.3$ following a $6^M.3$ star, which is BD +36°3744.

Found 9 November, 1909.

	°	″
1909.860	154.0	4.20
.865	154.8	4.40
.870	154.8	4.37
1909.865	154.5	4.32

ρ 21 BD +41°3969.

$20^h\ 59^m\ 3^s$ +41° 17′ ($9^M.5$, $9^M.7$).

Found 11 November, 1909.

1909.865	223.2	8.35
.870	223.2	8.91
.875	223.2	8.23
1909.870	223.2	8.49

ρ 22 BD +38°4395.

$21^h\ 9^m\ 16^s$ +38° 44′ (9^M, 10^M).

Found 28 November, 1908.

1909.915	150.0	13.54
.917	148.6	12.63
.919	149.7	12.56
1909.917	149.4	12.91

ρ 23 $21^h\ 17^m\ 48^s$ +36° 55′ (10^M, 10^M).

8′.2 north and 57^s following a 7^M star which is BD +36°4533.

Found 13 November, 1909.

	°	″
1909.917	86.1	9.91
.919	85.8	10.14
1909.918	85.9	10.02

ρ 24 $21^h\ 17^m\ 54^s$ +36° 56′ (10^M, 10^M).

1′ north and $6^s.6$ following ρ 23.

Found 13 November, 1909.

1909.917	169.6	10.28
.919	169.2	9.49
1909.918	169.4	9.88

ρ 24 A — ρ 23 A.

1909.917	267.1	70.99
.919	266.5	70.68
1909.918	266.8	70.83

Syracuse University, 1910 *February* 12.

ELEMENTS AND EPHEMERIS OF COMET α 1910,

By R. H. CURTISS.

The following parabolic elements of Comet a 1910, computed by the method of variation of geocentric distance, are based upon micrometric observations of Jan. 14, Feb. 4, and Feb. 7, by Professor Hussey, and a photographic position on Feb. 1, by Dr. H. D. Curtis. In view of the difficulty attending the micrometrical observation of this Comet, the residuals for the four places may be regarded as satisfactory. Indeed they indicate strongly that the orbit of Comet a 1910 is very nearly, if not quite, parabolic. According to these elements the Comet will be favorably placed for observation after the middle of April and any positions which may be secured either photographically or with large refractors will be of great value in the final determination of the orbit.

Elements of Comet a 1910.

T = 1910 Jan. 17.0881 Gr.M.T.

$$\left.\begin{aligned}\omega &= 320^\circ\ 46'\ 59''\\ \Omega &= 88\ \ 43\ \ \ 4\\ i &= 138\ \ 47\ \ 25\end{aligned}\right\}1910.0$$

$\log q = 9.10907$

Residuals, Observed — Computed.

	Jan. 24	Feb. 1	Feb. 4	Feb. 7
$\Delta\lambda\cos\beta$	+4″	+7″	−12″	+2″
$\Delta\beta$	+1	+8	− 2	+1

Constants for the Equator of 1910.0.

$$x = r[9.87648]\sin(322^\circ\ 29'\ 14'' + v$$
$$y = r[9.98149]\sin(\ 67\ \ 37\ \ 26 + v$$
$$z = r[9.85613]\sin(354\ \ 25\ \ 59 + v$$

Ephemeris for Greenwich Mean Midnight.

1910	True α	True δ	log	log r
d	h m s	° ′ ″		
Mar. 16.5	22 27 5.5	+16 21 36	0.37424	0.18701
20.5	22 29 35.7	17 9 27	0.38460	0.20749
24.5	22 31 52.3	17 56 31	0.39382	0.22667
28.5	22 33 56.0	18 42 57	0.40195	0.24467
Apr. 1.5	22 35 45.7	19 28 53	0.40914	0.26165
5.5	22 37 21.7	20 14 30	0.41542	0.27771
9.5	22 38 43.7	20 59 53	0.42088	0.29297
13.5	22 39 50.0	21 44 54	0.42555	0.30745
17.5	22 40 40.7	22 29 46	0.42953	0.32129
21.5	22 41 15.3	23 14 18	0.43283	0.33447
25.5	22 41 32.6	23 58 40	0.43552	0.34711
29.5	22 41 32.2	24 42 39	0.43767	0.35921
May 3.5	22 41 12.7	25 26 17	0.43931	0.37085
7.5	22 40 33.2	26 9 31	0.44047	0.38205
11.5	22 39 32.7	26 52 5	0.44121	0.39285
15.5	22 38 10.1	+27 33 52	0.44160	0.40327

ELEMENTS OF COMET α 1910,

By HERBERT R. MORGAN.

[Communicated by Captain T. E. De Witt Veeder, U.S.N., Superintendent, U.S. Naval Observatory.]

T = 1910 Jan. 17.06776, Gr. M.T.

$$\left.\begin{aligned}\omega &= 320^\circ\ 24'\ 14''\\ \Omega &= 88\ \ 57\ \ 57\\ i &= 138\ \ 36\ \ 46\end{aligned}\right\}\text{Ecliptic 1910.0}$$

$$\varphi = 81\ \ 30\ \ \ 0$$

$q = 0.12921$ $e = 0.9890$

$\mu = 87''.960$ $a = 11.7620$

$(O-C)$	Jan. 18	Jan. 24	Jan. 25	Feb. 4	Feb. 6	Feb. 10
$\Delta\lambda$ =	0″	+28″	+12″	0″	+ 8″	− 42″
$\Delta\beta$ =	0	+ 8	1	0	+31	+70

The distances for the observations at Rome, Jan 18, and Washington, Feb. 4, were varied to satisfy the observation at Washington, Jan. 25.

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Elements of Comet a 1910, by Herbert R. Morgan.

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PRECESSION AND SOLAR MOTION.

First Paper. Data and Preliminary Considerations.

By LEWIS BOSS.

The preparation of the *Preliminary General Catalogue of* 6188 *Stars*, now published, had placed me nearly two years ago, in possession of a large number of accurately computed proper-motions of stars distributed with approximate uniformity over the entire sky from one pole to the other. I then undertook to deduce the position of the solar-apex, with corrections to Newcomb's equinox of 1874, and Newcomb's precessions. Interruptions due to a variety of causes and principally to the labors incident to the establishment of a branch observatory at San Luis in Argentina, have conspired to delay publication of the essential points in that investigation until the present time. All the work has been done at the Dudley Observatory, which with the before mentioned branch observatory at San Luis, constitutes the *Department of Meridian Astrometry* of the Carnegie Institution of Washington.

The method I have adopted is that of rectangular coordinates for which the observed coordinates of the proper-motion designated as μ and μ' furnish the needed data. But instead of forming normal equations from conditional equations for each star, I have taken the mean result for each of 108 trapeziums, or sectors. Each area contains about 400 square degrees and they contain an average of about 50 stars. The means of all the values of μ and μ' for the separate stars within a given trapezium are treated as the μ and μ' attaching to a representative star near the center of each area.

The equations of condition were then formed in the following manner:

Let Δk represent the constant correction of all the values of μ, arising from whatever cause. We may suppose that:

$$\Delta k = \Delta' m - \Delta\lambda - \Delta e$$

where $\Delta' m$ equals the correction required for Newcomb's value of $p \cos \epsilon$ (p, being the Luni-Solar precession and ϵ the obliquity of the ecliptic for 1875); $\Delta\lambda$, the correction required for Newcomb's planetary precession, and Δe the required correction for Newcomb's value of the motion of the equinox published in 1874.

Let Δn be the correction of the constant of precession in declination for 1875,— $p \sin \epsilon$.

Let X, Y, Z be the rectangular coordinates of Solar-motion expressed in the usual manner.

Then each mean $\mu \cos \delta$ for a single area would give rise to the following conditional equations in right-ascension, assuming that the distances of the representative stars, one for each trapezium, are approximately the same and consequently eliminated:

$$\Delta k \cos \delta + n \sin \alpha \sin \delta + X \sin \alpha - Y \cos \alpha = \mu \cos \delta\,.$$

Each value of μ' gives a conditional equation in declination of the form:

$$n \cos \alpha + X \cos \alpha \sin \delta + Y \sin \alpha \sin \delta - Z \cos \delta = \mu'\,.$$

These were computed for each star, and then the mean of all the equations for stars within a given trapezium was taken as the equation of a representative star, rather than the equation which might have been computed from the mean α and δ corresponding to the representative star.

CHARACTER OF PROPER-MOTIONS EMPLOYED.

The proper-motions that form the basis of this discussion are taken from my *Preliminary General Catalogue of* 6188 *Stars*, recently published. These proper-motions have been computed with great care under my direction by the *Department of Meridian Astrometry* of the Carnegie Institution of Washington. This Department is located at the Dudley Observatory. In these computations which aimed to make use of all readily available data furnished by meridian observations published in Catalogue-form before 1906, very particular attention was paid to the systematic errors that affect the various catalogues of observations. Naturally errors of a casual nature also received close attention in the computation of each individual motion; but it was recognized from the beginning that in discussing problems concerning systematic motion of the stars, the point of first importance is to eliminate, so far as possible, systematic errors of observation in computing those motions. Partly from necessity and partly from failure to recognize their importance, the systematic errors which are produced by errors of observation have been hitherto very much neglected in many of the important discussions of the position of the solar apex and of the precession.

The nature of the efforts made in the Department, so far as practicable, to free from systematic errors of observation the proper-motions at the basis of this discussion, may be judged from various papers of mine published in Vol. XXIII of the *Astronomical Journal* upon the formation of a "Catalogue of 627 Fundamental Stars," which has constituted the systematic basis upon which rest the subsequent operations to form the *Preliminary General Catalogue* (*P.G.C.*). Further explanations are given in the Introduction and Appendices of the *P.G.C.* itself.

The *P.G.C.* aims to include all the stars down to the sixth magnitude from the North to the South pole, together with more than 2,000 stars, mostly contained between the magnitudes, $6^{M}.0$, $7^{M}.5$, for which the proper-motion can be determined with more than customary accuracy for the generality of stars within those limits of magnitude.

FUNDAMENTAL HYPOTHESES.

It will be necessary to form some hypotheses as to the general character and distribution of the stellar motions in space, not as something proved, but as something to be tested.

Let us suppose:

1. That — apart from the apparent parallactic drift due to the motion of the Sun through space — the peculiar motions of the stars (or systems of stars having motions in common) are at random, having no preference for one direction rather than another. This hypothesis may still be useful, if we merely postulate that the peculiar motions in a given volume of space and referred to a common origin O_2, are symmetrical about that origin; so that we may suppose that, in the mean of a large number, the resultant of all the peculiar motions tends towards zero.

2. That if we arrange the stars in the order of magnitude, it is likely that the mean distance of all the stars of a given order of magnitude in a given pyramidal volume of space will be the same as that for the same order of magnitude and a similar volume on the opposite side of the Sun; and in a general way, except for the effect of relation to the Galaxy, the same for all similar volumes in space.

3. In close connection with the preceding, let us suppose that the distribution of stars in each unit of volume tends toward equality except for the operation of the laws of pure chance, or on account of the relation of the volumes to the galactic latitude.

4. As a first approximation, let us suppose that in any given cone or pyramid in space (having its apex at the Sun) the mean proper-motion of stars contained in a given unit of volume, at the distance ρ, is proportional to $\frac{1}{\rho}$. Experience has rendered this supposition very probable, though it may not be at all rigorous.

ATTEMPT TO EQUALIZE THE ELEMENT OF DISTANCE IN THE FORMATION OF EQUATIONS.

The entire area of the sky was divided into 108 trapeziums and sectors, each containing an area of about 300 to 400 square degrees. Each trapezium may be supposed to be the cross section of a pyramid having its base at the distance of the most distant stars under consideration and its apex at the Sun. Take a section of the spherical shell at the distance of ρ from the Sun and within the limits of the pyramid already supposed. Conceive all the stars within that shell to be brought to a common origin at O_1 (see diagram). The apparent parallactic motion due to the Sun's way will be represented by the apparent motion of O_1 toward O_2, away from the solar apex in a direction opposite to that of A which is directed toward the apex. Now suppose that while the superimposed

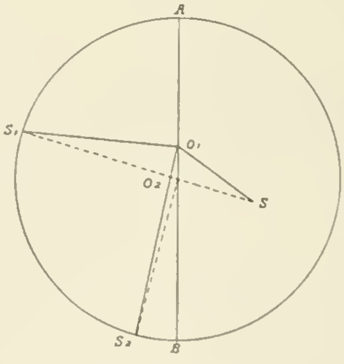

TABLE I. MATERIAL FOR CONDITIONAL EQUATIONS FROM TRAPEZIUMS.

No.	No. Stars	Mean Mag.	1875 R.A.	1875 Decl.	Mean μ_0	$\mu \cos \delta$	C − O	μ'	C − O
		M	h m	°	″	″	″	″	″
1	58	6.3	23 57	− 0.5	5.8	+1.5	+1.3	−1.5	−0.4
2	40	6.2	1 14	+ 0.4	6.7	+1.6	+1.0	−2.6	+0.7
3	34	5.6	2 41	− 1.0	5.3	+0.6	+1.5	−2.6	+0.7
4	45	5.5	4 5	+ 0.8	4.5	+1.6	−0.4	−1.9	−0.1
5	79	4.9	5 22	− 0.4	2.4	+0.2	+0.1	−1.2	−0.9
6	48	5.6	6 35	− 0.9	2.3	−0.5	−0.3	−1.0	−1.1
7	39	5.5	7 57	+ 0.1	4.9	−1.9	+0.1	−1.1	−1.2
8	39	5.7	9 22	− 0.7	5.8	−3.0	+0.3	−1.9	−0.4
9	54	6.3	10 36	+ 1.6	6.2	−3.0	−0.3	−2.8	+0.4
10	43	6.2	12 1	− 0.2	6.1	−3.7	+0.2	−2.0	−0.4
11	42	6.4	13 22	− 4.5	5.7	−3.6	+0.3	−2.1	−0.4
12	32	5.7	14 37	− 1.4	8.7	−4.6	+1.8	−3.4	+1.0
13	39	5.5	16 1	+ 0.6	6.6	−1.7	−0.3	−2.4	+0.1
14	33	5.5	17 26	− 0.4	5.3	−0.6	−0.2	−2.6	+0.4
15	43	5.5	18 42	+ 0.3	4.5	+0.0	+0.2	−2.2	+0.1
16	32	5.7	19 57	− 1.0	4.1	+1.9	−0.7	−2.0	−0.1
17	52	5.7	21 22	− 1.3	4.9	+1.6	+0.5	−2.1	+0.1
18	51	6.0	22 39	− 3.2	5.3	+2.5	+0.1	−1.4	−0.6
19	45	5.8	0 40	+19.2	5.8	+3.1	−0.3	−1.8	−0.2
20	55	6.0	2 1	+19.3	7.4	+3.1	−0.6	−3.0	+0.6
21	61	5.6	3 22	+21.8	5.6	+2.3	−0.5	−3.9	+1.2
22	57	5.8	4 41	+19.8	4.9	+1.6	−0.7	−3.4	+0.4
23	80	5.7	5 58	+19.6	3.2	+0.5	−0.7	−2.4	−0.7
24	61	5.8	7 20	+20.9	4.6	−1.8	+0.6	−3.1	−0.0
25	67	6.4	8 40	+20.1	6.0	−2.6	+0.3	−3.7	+0.6
26	38	6.0	9 57	+17.8	6.2	−3.1	+0.1	−3.1	+0.4
27	26	5.9	11 16	+20.1	6.1	−3.9	+0.5	−2.2	−0.3
28	50	5.9	12 33	+20.6	5.5	−1.8	−1.7	−2.4	+0.3
29	31	5.6	14 3	+20.1	7.5	−2.9	−0.2	−2.6	+0.9
30	37	5.5	15 27	+20.2	6.6	−2.5	+0.1	−1.6	+0.3
31	44	5.7	16 42	+19.2	5.4	−1.4	−0.1	−3.2	+2.1
32	41	5.6	17 56	+22.9	3.9	−0.1	−0.4	−0.2	−0.5
33	64	5.4	19 25	+19.2	3.6	+1.0	−0.3	−0.3	−0.6
34	48	5.5	20 32	+20.4	4.4	+1.6	0.0	−0.8	−0.2
35	39	5.7	22 1	+21.1	5.8	+2.4	0.0	−1.8	+0.6
36	27	5.5	23 21	+20.4	6.2	+3.6	−0.8	−2.0	+0.4
37	24	5.9	0 35	−19.2	6.1	+2.7	+0.1	−0.7	−1.0
38	26	5.7	1 58	−20.2	7.1	+3.3	−0.9	−1.7	+0.4
39	30	5.6	3 25	−21.0	5.4	+2.1	−0.4	+0.5	−1.5
40	39	5.5	4 50	−18.8	5.1	+1.6	−1.0	−1.6	+0.6
41	48	5.4	6 0	−19.1	3.9	+0.2	−0.6	−0.4	−0.6
42	79	5.2	7 18	−21.5	3.0	−1.7	+0.2	0.0	−1.0
43	37	5.7	8 37	−20.4	5.3	−2.5	+0.1	−1.2	−0.1
44	35	6.0	10 1	−20.4	6.2	−4.8	+1.7	−0.2	−1.5
45	27	6.0	11 17	−20.8	7.8	−3.6	+0.2	−0.4	−1.6
46	35	5.7	12 40	−19.5	7.2	−3.6	+0.2	−2.5	+0.1
47	45	6.1	13 59	−21.1	6.6	−3.8	+0.8	−2.9	+0.1
48	68	5.6	15 24	−20.2	5.9	−2.7	+0.4	−4.0	+1.0
49	66	5.7	16 41	−21.5	5.6	−0.6	−0.8	−3.4	+0.2
50	70	5.9	18 6	−21.0	3.3	−0.1	−0.0	−2.1	−1.0
51	77	6.0	19 18	−20.6	4.6	+1.1	−0.3	−2.1	−0.9
52	73	6.1	20 42	−19.6	5.8	+2.0	−0.2	−3.4	+0.8
53	63	6.3	22 0	−19.0	5.9	+3.8	−1.3	−1.5	−0.9
54	47	5.8	23 22	−19.0	5.7	+1.6	+1.2	−1.4	−0.6
55	44	5.5	0 51	+40.9	5.5	+2.7	+0.1	−1.7	−0.1
56	53	5.2	2 42	+41.1	5.1	+1.9	+0.4	−2.5	−0.3
57	50	5.2	4 19	+40.4	4.6	+1.6	−0.4	−3.3	−0.1
58	52	5.6	5 58	+40.2	5.4	+0.2	−0.3	−4.2	+0.6
59	31	5.7	7 39	+40.8	6.2	−0.9	−0.5	−3.8	+0.2
60	45	5.8	9 24	+38.1	7.1	−2.6	0.0	−4.1	+1.0
61	38	5.7	10 55	+38.9	7.6	−4.5	+1.3	−3.4	+1.0
62	32	5.8	13 0	+40.9	6.9	−4.9	+1.6	−1.2	−0.2
63	33	5.8	14 46	+40.1	6.7	−3.3	+0.6	1.3	+0.8
64	44	5.7	16 21	+39.1	5.4	−1.2	−0.6	−0.7	+0.7
65	50	5.6	18 7	+39.6	3.7	1.1	+0.8	0.0	+0.3
66	79	5.7	19 50	+39.7	3.3	+0.8	+0.3	0.7	+0.9
67	59	5.5	21 20	+41.4	3.7	+1.8	+0.2	+0.1	−0.2
68	48	5.6	23 2	+11.9	4.3	+2.4	+0.4	−0.7	−0.1
69	42	6.0	0 53	−38.9	6.2	+2.5	+0.3	−2.1	+1.1
70	50	6.2	2 37	−39.3	6.2	+2.3	−0.2	−1.1	+0.9
71	46	6.0	4 18	−39.1	5.0	+0.7	+0.3	−0.3	+0.5
72	96	6.0	6 6	−37.8	3.6	−0.4	−0.0	+0.2	0.0
73	107	5.4	7 46	−39.9	3.1	−1.9	+0.2	−0.3	+0.4
74	68	5.6	9 16	−41.3	4.3	−2.2	−0.6	−1.1	+0.7
75	43	5.6	11 7	−39.1	6.6	−4.4	+1.0	−1.4	−0.1
76	47	5.5	12 49	−41.0	6.5	−4.2	+0.9	−3.0	+0.7
77	66	5.0	14 36	−41.2	5.2	−3.2	+0.6	−3.3	+0.2
78	52	5.4	16 20	−40.2	3.9	−1.0	−0.5	−2.5	−1.1
79	65	5.3	18 4	−39.4	4.6	−0.6	+0.5	−3.4	−0.3
80	41	5.6	19 35	−38.5	5.6	+2.6	−1.5	−3.0	−0.4
81	38	5.6	21 21	−38.2	6.7	+2.9	−0.6	−3.2	+0.4
82	43	5.6	23 4	−38.6	6.5	+2.2	+0.6	−2.9	+1.0
83	74	5.8	1 19	+58.8	3.7	+2.3	+0.6	−1.1	−0.7
84	56	5.5	3 58	+58.7	4.0	+1.6	0.0	−2.2	−1.1
85	67	6.2	6 38	+59.2	4.5	+0.6	−1.1	−2.8	−1.0
86	59	5.9	9 13	+60.4	6.5	−2.2	−0.2	−2.7	−0.3
87	40	5.4	11 59	+58.6	6.1	−0.6	−2.7	−1.5	+0.1
88	39	5.9	14 37	+57.7	5.8	−3.0	+0.3	+0.6	−0.3
89	47	5.7	17 24	+59.4	5.1	+0.3	−1.2	+2.2	−0.7
90	71	5.9	19 55	+58.1	4.6	+1.7	−0.6	+1.3	0.0
91	89	6.1	22 33	+59.4	3.8	+2.1	+0.6	+0.4	−0.3
92	40	5.7	1 29	−59.8	5.6	+2.4	+0.2	−0.3	+0.4
93	36	5.7	4 0	−60.2	5.6	+0.5	+0.7	+2.6	−1.2
94	56	5.5	6 42	−57.3	4.9	−1.6	+0.7	+1.0	+0.4
95	100	5.1	9 26	−58.2	3.9	−2.3	−0.4	−0.2	+0.5
96	87	5.1	12 1	−59.7	4.4	−2.7	−0.6	−1.6	+0.3
97	58	5.4	14 37	−59.2	6.0	−3.0	+0.5	−4.0	+1.0
98	47	5.3	17 7	−59.7	4.8	−0.8	+0.1	−3.8	+0.1
99	41	5.4	19 53	−59.1	6.6	+1.6	−0.1	−3.2	−0.2
100	33	5.5	22 53	−59.1	6.6	+3.1	−0.2	−0.6	−1.1
101_1	27	5.9	1 13	+77.7	5.8	+1.9	+1.1	+0.0	−1.2
101_2	26	6.1	3 59	+78.6	6.0	+2.4	−0.7	−2.6	−0.3
102_1	19	6.4	7 25	+80.4	4.6	+0.1	−1.0	−3.0	−0.4
102_2	20	6.0	10 14	+78.8	6.6	−4.2	+1.4	−1.0	−1.0
103_1	22	5.8	13 6	+78.3	4.8	−3.0	−0.1	+0.4	−0.2
103_2	21	6.2	15 55	+77.2	3.6	−1.8	−0.0	+1.4	+0.5
104_1	31	6.1	19 50	+78.5	5.8	+1.5	−0.3	+0.8	+1.5
104_2	32	6.2	22 34	+77.2	5.4	+2.8	−0.1	+0.4	+0.5
105_1	17	5.9	1 22	−78.7	7.1	+3.2	−0.5	+1.2	−0.4
105_2	17	6.0	4 14	−76.6	6.4	+0.5	+0.6	+4.2	−2.0
106_1	23	5.6	8 16	−77.4	5.4	−2.5	+0.6	+3.2	−1.3
106_2	24	5.7	10 45	−76.9	5.0	−3.7	+0.6	−0.3	+0.6
107_1	19	5.7	13 4	−79.9	4.9	−2.9	−0.1	−1.8	+0.4
107_2	20	5.8	15 31	−79.2	7.1	−2.4	+0.6	−2.5	−0.4
108_1	16	5.7	20 12	−77.1	6.2	+1.5	+0.2	−3.6	+0.8
108_2	14	5.9	23 2	−79.8	4.6	−0.3	+3.3	−0.1	−0.9

stars at O_1, are moving toward O_2, during the unit of time, the individual, real, or peculiar, motions are radiating outward in all directions at random.

At the end of the unit of time, when the center of motion shall have reached the point O_2, the appearance of the cluster, if we assume MAXWELL'S law as to velocities in the Kinetic theory of gases, will be that of a globular cluster, more or less condensed around the point O_2. The resultant of all the peculiar motions will be O_2.

The actual proper-motions of the stars as we observe them projected on the sky will be $O_1 S$. This is the resultant of $O_1 O_2$ (the parallactic motion projected on the sky) and $O_2 S$, the projected motion peculiar to the star itself. S may lie anywhere within the diagram.

Resolve the proper-motion, μ_0, into coordinates $\mu \cos \delta$ and μ'. The mean of all these coordinates contained in the supposed unit of volume would evidently be the corresponding coordinates of the parallactic motion, $M \sin \Delta$, where Δ represents the polar distance from the solar apex. In the diagram this quantity is represented by $O_1 O_2$.

It is found that the mean of all the values, μ_0, of the apparent proper-motion projected on the sky within a given volume, under our hypotheses, sustains rather interesting relations with the means of the peculiar motions, and with the projected parallactic motion. Mr. H. RAYMOND of this Observatory, has investigated these relations in his paper published in No. 607 of the *Astronomical Journal*.

We may now conceive the entire pyramid to be composed of thin shells at distances from the Sun $\rho_1, \rho_2 \ldots \rho_n$, each of which will furnish a diagram, in all respects similar to that which corresponds to that for ρ, as already described, but of relative scales proportional to $\frac{\rho}{\rho_1}$, and so forth. In superimposing these, the point O_1 will be the fixed origin and the condensations around O_2 will be drawn out into comparatively small area elongated in the direction $O_2 O_1$.

If we wish to exclude the large proper-motions, such as are clearly abnormal, like that of GROOMBRIDGE 1830, or those of stars comparatively near the Sun where the numbers of stars in our imagined pyramid are apt to be few, we shall prevent the distorting effects upon our equations of motions which abnormally depart from the mean.

The objection to the retention in our equations of very large proper-motions, due to the relatively large values of $\frac{1}{\rho}$, is that there are too few of these stars in any one section of the pyramid to illustrate the law of symmetrical distribution.

The brute mean of all the values of $\mu \cos \delta$ and μ', within a trapezium for stars at all distances, does not yield a mean result that is consistent with the mean which we might form if the value of ρ were known for each star, mainly because the weights virtually attributed to the larger motions exercise an undue influence upon the mean. But it is probable that the relation of mean μ_0 to mean $\mu \cos \delta$ and mean μ' would be approximately illustrative of what would be true of the stars of a comparatively thin shell, having ρ such that a value of mean μ_0 for that shell would be equal to the value of μ_0 as we find it from the trapezium. At the same time it is necessary to remember that the mean of the values of $\mu \cos \delta$ and μ' does not correspond to the mean of all the distances of the several stars.

After mature examination I have decided to exclude from the main solution all stars having a proper-motion greater than 20″. But it would manifestly be incorrect to establish the same criterion for rejection at all position angles from O_1 (see diagram). If we can base our rejection virtually upon the projected values of the peculiar-motion of which the origin is O_2 we shall preserve the symmetry of our rejections. Accordingly I have effected the rejections graphically in the following manner:

Assume the distance $O_1 O_2$, the observed parallactic motion that is to result from each trapezium, to be 3″.3 sin Δ; in which Δ is the polar distance from the Apex of the star representing the trapezium. Lay off this distance from O_2 toward A. The point O_1 represents the common origin of all the proper-motions of stars within the trapeziums. Around O_2 as a center draw the circle $AS_1 S_2 B$, having radius 16″.7. $O_1 A$, $O_1 S_1$, $O_1 S_2$ etc. represent the limits of symmetrical rejection which were adopted at different position-angles around O_1 referred to the apex. Thus we shall have for illustration (omitting intermediate position-angles) when Δ equals 90° and 30° respectively:

Pos.-Ang.	$\Delta = 90°$	30°
°	″	″
0	13.4	15.0
90	16.4	16.6
180	20.0	18.3
270	16.4	16.6

The position of the Apex assumed was: $A = 275°$; $D = +40°$. Subsequent results showed that it would have been more accurate to have used $M = 3''.85$ rather than the actual 3″.3 employed, with a very considerable change for the apex of solar motion. Yet the number of stars to be admitted or excluded by a second approximation would have been surprisingly few.

In this process we have converted our pyramids into frustrums of pyramids not well defined at either limit. There will still remain in the mean values of $\mu \cos \delta$ and

μ', the motions of stars situated at the lower limit of distance (nominally ρ_1, say) which really belong to a still smaller value of ρ. The effect of these must certainly be objectionable, but is unavoidable. Yet the ill effect is certainly less than it would have been for the larger excluded motions, corresponding to the distance ρ_1; and more exact research will probably show that the number of included values of motions really corresponding to ρ_1 (or to a smaller ρ) is really very small, and that even these tend to compensate when several equations are combined. Furthermore, it is to be noted that the danger of ill effect upon the resulting values for precession and position of the Apex are likely to be relatively less than for the value of M (the Sun's parallactic motion) relative to μ_0, the mean of all the proper-motions employed in the solution.

It should also be stated that it has been assumed that the solar motion is decidedly less than the mean motion of the stars, and that M is decidedly less than μ_0 — assumptions that seem to be abundantly justified — as may be shown in a future communication.

The rejections of large proper-motions were supplemented by the employment of only one star to represent a double or triple star. There are many cases of two or three stars, several minutes asunder, which have closely accordant proper-motions. Each of these was condensed into one mean star representing the whole, except in the case of the moving cluster in *Taurus* (*A.J.* 604) when 4 stars taken at random were employed as representative of the entire 41 stars therein.

Accordingly, there entered into the main solution 5413 stars having a mean magnitude of $5^M.7$. Of these 3,549 are of the sixth magnitude, or brighter, and a separate solution was made for these, of which the mean magnitude is $5^M.2$. The mean of the 1864 stars below the sixth magnitude included in the main solution was $6^M.7$ and this quantity was fairly constant in all areas.

Each area contained 50 stars in the mean; but it is notable that the 18 areas nearest the Galaxy (centers never more than 7° of Galactic latitude) contain 70 stars in the mean.

It also appears on inspection that the areas close to the Galaxy have, in general, much smaller values of mean μ_0 than the corresponding areas of greater Galactic latitude.

Table I contains the chief data that led to the main solution. The areas are arranged in the order of declination. The headings of the columns seem to be mostly self-explanatory. Each line forms a mean into which is condensed the testimony of all the stars contained in a given trapezium upon a single representative star near the center of the trapezium. μ_0 is the mean of the total motions of the stars. $\mu \cos \delta$ is the mean observed value of the motion in right-ascension converted into arc of a great circle; and μ', the corresponding quantity in declination. C — O are the residuals arising from comparison of the values of $\mu \cos \delta$ and μ', arising from substitution of the concluded values of the unknowns in the separate conditional equations, compared with the observed values given in Table I.

Publication of the results of various solutions based upon this table, as well as upon further material, must be deferred to another opportunity.

OBSERVATIONS OF HALLEY'S COMET,

MADE WITH THE 12½-INCH TELESCOPE AND FILAR MICROMETER OF THE EMERSON MCMILLAN OBSERVATORY OF THE OHIO STATE UNIVERSITY,

By E. S MANSON, Jr.

G.M.T. 1910	$\Delta\alpha$	$\Delta\delta$	Comp.	App. α	App. δ	log $p\Delta$	Star
h m s	m s	′ ″		h m s	° ′ ″		
Feb. 4 12 50 21	+2 19.3	−0 35	8 , 8	0 58 20.1	+8 12 21	9.537 0.694	1
Feb. 6 12 40 21	−0 15.4	−4 43	8 , 8	0 55 45.3	+8 8 13	9.538 0.696	1

Mean Place of Comparison-Star for 1910.0.

α	Red. to App.	δ	Red. to App.	Authority
h m s	s	° ′ ″	″	
0 56 2.03	−1.25 −1.27	+8 13 1.2	−5.9 −6.0	A.G. Leipzig 349

The above positions of the comet reduced to mean place agree with those given by the ephemeris in the *Astronomical Journal*, No. 607, p. 62, within less than two seconds of time in right-ascension and within about one-tenth of a minute of arc in declination; the sign of O − C being positive in the case of right-ascension and negative in the case of declination.

Columbus, Ohio, 1910 *March* 14.

ELEMENTS AND EPHEMERIS OF COMET a 1910,

By HERBERT R. MORGAN.

[Communicated by Captain T. E. De Witt Veeder, U.S.N., Superintendent, U.S. Naval Observatory.]

Approximate elements, from my previous computations, gave the geocentric distances of the comet for the observations, at Rome, Jan. 18, and at Washington, Feb. 4. The ratio (M), of these distances, was varied for three sets of parabolic elements; and the corresponding residuals, in λ and β, for an observation at Washington, Jan. 25. Log M was then varied in direct proportion to $\Delta\lambda$ and $\Delta\beta$; this gave the following elements:

Elements.

$$T = 1910 \text{ Jan. } 17.08840, \text{ Gr. M.T.}$$

$$\left.\begin{aligned} \omega &= 320^\circ\ 53'\ 47'' \\ \Omega &= 88\ \ 46\ \ 44 \\ i &= 138\ \ 46\ \ 36 \end{aligned}\right\} \begin{array}{l}\text{Ecliptic} \\ 1910.0\end{array}$$

$$\log q = 9.11050$$

$$(\text{O}-\text{C}) \begin{cases} \cos\beta\,\Delta\lambda = -3'' \\ \qquad\ \Delta\beta = -9 \end{cases}$$

Constants for the Equator.

$$\begin{aligned} x &= r[9.87637] \sin (v + 322^\circ\ 31'\ 11'') \\ y &= r[9.98141] \sin (v + \ \ 67\ \ 41\ \ 56) \\ z &= r[9.85637] \sin (v + 354\ \ 31\ \ 34) \end{aligned}$$

Note: In Pasquier's French Edition (1886), of Oppolzer, Vol. I, the "Errata" to page 476 should be for page 474.

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* This article was accompanied with an Ephemeris that gave in comparison with the Ephemeris of Curtiss in this number, April 26.0, Morgan—Curtiss Δa — 0s.4 $\Delta\delta$ — 18″. —Ed.

OBSERVATIONS OF COMETS,

MADE WITH THE 26-INCH AND THE 12-INCH EQUATORIALS AT THE U.S. NAVAL OBSERVATORY,

By J. B. EPPES.

Communicated by Captain T. E. De Witt Veeder, U. S. N., Superintendent.

1909–10 Wash. M.T.		∗	Comp.	Δa	$\Delta\delta$	App. a	App. δ	log $p\Delta$		Red. to App. Pl.	
					Halley's Comet.						
1909	h m s			m s	′ ″	h m s	° ′ ″			s	″
Dec. 10	8 35 46	1	25 , 5	−1 25.47	− 2 6.9	3 47 19.16	+14 52 58.6	n9.357	0.576	+3.35	+12.9
15	8 52 17	2	25 , 5	+0 59.80	+ 7 34.1	3 25 5.65	14 10 53.3	n9.061	0.568	+3.28	+14.1
1910 Jan. 3	8 43 29	3	25 , 5	−1 47.02	+12 28.9	2 9 15.78	11 8 57.5	9.230	0.619	−0.48	− 1.2
7	7 21 31	4	25 , 5	−1 29.24	− 0 5.9	1 56 39.49	10 34 58.3	8.806	0.619	−0.60	− 1.9
15	7 31 40	5	30 , 6	+1 1.76	+10 1.0	1 34 49.04	9 36 23.7	9.272	0.695	−0.81	− 3.1
Feb. 7	7 43 15	6	25 , 5	−2 10.41	+ 8 26.0	0 54 30.50	8 6 18.8	9.600	0.695	−1.27	− 6.1
10	7 34 51	7	25 , 5	+1 1.27	− 3 20.1	0 51 0.13	+ 8 1 36.4	9.607	0.697	−1.33	− 6.3
					Comet 1909 e (Daniel).						
1909 Dec. 10	9 7 59	8	25 , 5	−1 18.14	− 4 20.2	6 17 26.58	+37 10 24.9	n9.688	0.342	+4.20	+ 0.2
15	12 1 48	9	24 , 5	−0 52.06	− 1 3.7	6 18 3.60	41 12 42.8	n9.017	n9.496	+4.52	+ 0.3
1910 Jan. 10	9 9 45	10	25 , 5	−0 42.11	− 0 23.3	6 18 12.07	54 24 41.6	n9.558	n0.243	+0.98	+ 6.1
15	8 11 38	11	29 . 6	−0 33.87	− 2 2.0	6 19 55.71	+55 28 59.9	n9.691	0.426	+1.06	+ 7.3
					Comet 1910 a.						
1910 Jan. 25	6 16 22	12	19 , 4	−6 2.53	+ 1 23.8	21 17 36.47	− 3 15 24.9	9.653	0.745	−1.90	−10.7
Feb. 2	6 39 14	13	15 , 3	−1 53.18	− 6 25.6	21 40 43.54	+ 3 52 35.9	9.660	0.737	−1.87	−10.7
4	6 18 19	14	30 , 7	+0 7.20	+ 7 27.5	21 44 37.44	+ 5 0 2.7	9.658	0.732	−1.86	−10.7

Comet 1910 a was observed with the 12-inch equatorial, the other two on the 26-inch.

Mean Places of Comparison-Stars for the beginning of the Year.

∗	a	δ	Authority	∗	a	δ	Authority
	h m s	° ′ ″			h m s	° ′ ″	
1	3 48 41.28	+14 54 52.6	A.G. Leipzig I. 1132	8	6 18 40.52	+37 14 41.9	A.G. Lund 3275
2	3 24 2.57	14 3 5.1	" " I. 1018	9	6 18 51.14	41 13 46.2	A.G. Bonn 5230
3	2 11 3.28	10 56 29.8	" " I. 668	10	6 18 53.20	51 21 58.8	A.G. Camb. U.S. 2497
4	1 58 9.33	10 35 6.1	" " I. 610	11	6 20 28.52	+55 30 51.6	A.G. Hels-Gotha 4508
5	1 33 48.09	9 26 25.8	" " II. 611	12	21 23 10.90	− 3 16 38.0	A.G. Strassburg 7499
6	0 56 12.18	7 57 58.9	" " II. 355	13	21 12 38.59	+ 3 59 12.2	A.G. Albany 7600
7	0 50 0.19	+ 8 5 2.8	" " II. 308	14	21 11 32.10	+ 4 52 45.9	" " 7614

OBSERVATIONS OF MINOR PLANETS,

MADE WITH THE 16-INCH EQUATORIAL AT THE CINCINNATI OBSERVATORY,

By EVERETT I. YOWELL.

1909–10 Cin. M.T.	*	Comp.	Δα	Δδ	App. α	App. δ	log pΔ		Red. to App. Pl.	
1909 H Z. Mag. 10.5 in Oct.										
h m s			m s	′ ″	h m s	° ′ ″			s	″
Oct. 24 11 12 36	1	3 , 8	+0 57.73	− 1 22.6	1 43 7.81	+23 55 9.7	n8.561	0.358	+2.86	+17.5
25 10 23 20	1	10 , 8	+0 8.68	− 9 8.0	1 42 18.76	+23 47 24.4	n9.135	0.398	+2.86	+17.6
27 10 40 45	2	0 , 4	....	+ 6 57.4	....	+23 30 58.2	.....	0.389	.....	+17.9
27 10 55 6	2	9 , 0	+1 3.53	....	1 40 48.70	....	n9.226	....	+2.86	.....
Dec. 9 11 37 4	3	9 , 6	−0 10.30	−16 32.3	1 26 13.71	+17 48 4.3	9.570	0.596	+2.69	+19.5
1909 J A. Mag. 10.5.										
Nov. 24 11 52 17	4	0 , 8	....	+12 52.0	....	+15 44 24.4	.....	0.555	.....	+14.0
24 12 42 20	4	12 , 0	−0 4.09	....	3 31 54.42	....	9.234	....	+3.20	.....
1909 J B. Mag. 11.0.										
Nov. 30 11 42 4	6	12 , 8	−0 53.09	+ 5 45.6	3 33 33.47	+32 36 48.0	9.036	0.009	+3.66	+15.1
Dec. 4 8 23 28	7	12 , 8	+0 36.77	+11 54.8	3 30 1.10	+31 54 59.8	n9.472	0.225	+3.63	+15.9
9 10 1 5	8	10 , 6	−0 58.46	−10 31.7	3 25 56.31	+30 59 2.3	n8.441	0.089	+3.60	+16.3
(122) *Gerda.*										
1910 Feb. 4 10 4 50	9	9 , 8	−1 15.49	+ 2 58.2	8 44 40.56	+16 17 17.6	n9.312	0.553	+0.79	0.0
5 9 15 53	10	10 , 6	+0 40.62	+17 4.3	8 43 54.06	+16 20 41.1	n9.453	0.575	+0.80	0.0
10 11 44 23	11	13 , 8	+0 31.00	− 5 49.2	8 39 54.42	+16 38 14.7	8.765	0.525	+0.83	+ 0.2

Mean Places for 1909.0–10.0 of Comparison-Stars.

*	α	δ	Authority	*	α	δ	Authority
	h m s	° ′ ″			h m s	° ′ ″	
1	1 42 7.22	+23 56 14.8	Berlin (B), A.G. 530	7	3 29 20.70	+31 42 49.1	Leiden, A.G. 1348
2	1 39 42.31	+23 23 42.9	" " " 519	8	3 26 51.17	+31 9 17.7	" " 1335
3	1 26 21.32	+18 4 17.1	Berlin (A), A.G. 434		1910.0	1910.0	
4	3 31 55.31	+15 31 18.4	Comp. with 5	9	8 45 55.26	+16 14 19.4	Berlin (A), A.G. 3548
5	3 32 41.23	+15 7 56.4	Berlin (A), A.G. 972	10	8 43 12.64	+16 3 36.8	" " " 3532
6	3 34 22.90	+32 30 47.3	Leiden, A.G. 1377	11	8 39 22.59	+16 44 3.7	" " " 3499

EPHEMERIS OF HALLEY'S COMET,

By GEORGE M. SEARLE.

Gr. M. Noon	α	δ	log r	log Δ	Br. Sept. 11 =1	Gr. M. Noon	α	δ	log r	log Δ	Br. Sept. 11 =1
1910	h m	° ′				1910	h m	° ′			
Apr. 9	0 0.9	+7 58	9.8019	0.1820	157	May 3	23 56.1	+ 8 27	9.8163	9.8544	667
13	23 57.2	53	7821	1508	199	7	0 6.5	9 19	8433	7463	968
17	53.9	49	7710	1132	249	11	0 29.1	11 2	8724	6038	1645
21	51.4	47	7693	0660	312	15	1 28.0	14 27	9023	4138	3405
25	50.4	50	7772	0.0093	394	19	3 58.7	19 48	9319	1973	8055
29	51.0	+7 59	9.7950	9.9400	494	23	7 43.1	12 46	9608	2868	4656
						27	9 12.9	+ 5 52	9.9885	9.5056	1500

SECOND ELEMENTS AND EPHEMERIS OF COMET α 1910,

By R. H. CURTISS.

In view of the probability that Comet a 1910 will be followed by telescopes of great aperture for several months to come I have derived a second set of parabolic elements based upon a long arc and have prepared from them the accompanying improved ephemeris.

These elements depend upon Professor HUSSEY's observations of January 24 and February 7 and upon Dr. AITKEN's position of March 13. Although the time intervals between these observations are unequal the corresponding changes in the comet's position between successive dates is such as to render the results quite determinate.

Because of the uncertain character of the early observations of this comet as indicated by the orbits based upon them, I have not employed positions antedating Professor HUSSEY's direct micrometer comparison of January 24th.

The residuals from the three observations given below furnish strong evidence of the parabolic form of the orbit.

PARABOLIC ELEMENTS OF COMET a 1910.

$$T = 1910 \text{ Jan. } 17.0886 \text{ Gr.M.T.}$$

$$\left.\begin{aligned} \omega &= 320^\circ\ 53'\ 17'' \\ \Omega &= 88\ \ 46\ \ 24 \\ i &= 138\ \ 47\ \ \ 8 \end{aligned}\right\} 1910.0$$

$$\log q = 9.11030$$

RESIDUALS: OBSERVED — COMPUTED.

	Jan. 24	Feb. 7	March 13
	"	"	"
$\varDelta\lambda \cos\beta$	+4	+1	−5
$\varDelta\beta$	+2	±0	+4

CONSTANTS FOR THE EQUATOR 1910.0.

$$x = r\,[9.87644] \sin(322^\circ\ 31'\ \ 7'' + v)$$
$$y = r\,[9.98141] \sin(\ 67\ \ 41\ \ 29 + v)$$
$$z = r\,[9.85630] \sin(354\ \ 31\ \ 24 + v)$$

EPHEMERIS FOR GREENWICH MEAN MIDNIGHT.

1910	True a	True δ	log Δ	log r
d	h m s	° ' "		
Mar. 16.5	22 27 5.0	+16 21 2	0.37420	0.18694
20.5	22 29 35.0	17 8 50	0.38456	
24.5	22 31 51.5	17 55 51	0.39378	
Mar. 28.5	22 33 55.1	18 42 15	0.40190	
Apr. 1.5	22 35 44.7	19 28 9	0.40909	0.26158
5.5	22 37 20.6	20 13 44	0.41536	
9.5	22 38 42.5	20 59 5	0.42082	
13.5	22 39 48.6	21 44 4	0.42548	
17.5	22 40 39.2	22 28 53	0.42946	0.32120
21.5	22 41 13.6	23 13 23	0.43275	
25.5	22 41 30.8	23 57 43	0.43544	
Apr. 29.5	22 41 30.3	24 41 39	0.43758	
May 3.5	22 41 10.5	25 25 15	0.43921	0.37082
7.5	22 40 30.9	26 8 27	0.44036	
11.5	22 39 30.2	26 50 59	0.44109	
15.5	22 38 7.4	27 32 44	0.44147	
19.5	22 36 21.6	28 13 32	0.44154	0.41326
23.5	22 34 11.8	28 53 12	0.44133	
May 27.5	22 31 37.0	29 31 34	0.44086	0.43240

Detroit Observatory, University of Michigan, 1910 *March* 22.

OBSERVATION OF COMET α 1910,

MADE WITH THE 26-INCH EQUATORIAL AT THE U.S. NAVAL OBSERVATORY

By J. B. EPPES.

[Communicated by Captain T. E. DE WITT VEEDER, U. S. N. Superintendent.]

1910 W.M.T.	Comp.	$\varDelta a$	$\varDelta\delta$	App. a	App. δ	log $p\Delta$	Red. to App. Pl.
h m s		m s	' "	h m s	° ' "		s "
April 9 16 0 42	18 . 6	+1 18.40	+5 41.3	22 38 47.71	+21 3 12.8	n9.686 0.680	−1.25 −14.2

Mean Place of Comparison-Star for the beginning of the Year.

a	δ	Authority
h m s	° ' "	
22 37 30.56	+20 57 45.7	A.G. Berlin B, 8719

Seeing good, comet very faint. Searched for it on the following morning when the seeing was fair, and did not find it.

This observation gives the following corrections to the Ephemeris of Mr. MORGAN (*A.J.* No. 612), $\varDelta a = -0^s.9$ $\varDelta\delta = -17''$.

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OBSERVATIONS OF LONG-PERIOD VARIABLES,

By MARY W WHITNEY and CAROLINE E. FURNESS.

The predicted maxima and minima in this article are taken from Hartwig's ephemerides in the *Vierteljahrsschrift* for 1909 and 1910.

T Aquarii. Ten observations extending from Aug. 13, 1909, to Jan. 8, 1910, indicate a maximum of $8^{M}.6$ on Aug. 17, and give a well determined minimum of $13^{M}.4$ on Dec. 2. Predicted maximum, Aug. 29; minimum, Dec. 25.

V Aurigae. Seven observations extending from Jan. 12, 1910, to April 10, give a maximum of $8^{M}.7$ on Feb. 14, in close agreement with the predicted maximum on Feb. 12.

X Aurigae. Six observations extending from Dec. 10, 1909, to April 10, 1910, indicate a maximum of $8^{M}.1$ about Feb. 12. Predicted maximum, Feb. 1.

V Cassiopeiae. Fifteen observations extending from Aug. 23, 1909, to April 10, 1910, indicate a maximum on or before Aug. 15, on which date it was $8^{M}.0$. Predicted maximum, Sept. 26, or forty-two days later. A minimum occurred on Dec. 3 of $12^{M}.6$, fifty-seven days before the predicted minimum of Jan. 29; and a second maximum of $8^{M}.2$ on Mar. 23, 1910, which is fifty-four days earlier than the predicted date, May 16.

W Cassiopeiae. Twelve observations extending from Oct. 7, 1909, to April 10, 1910, give a maximum of $8^{M}.9$ on Nov. 12, 1909. Predicted date, Nov. 28. The magnitude on April 10 was $11^{M}.4$.

S Cephei. Twelve observations cover the period from Jan. 28, 1909, to April 2, 1910. These give a maximum of $8^{M}.3$ on June 25, 1909, and indicate a minimum of $10^{M}.8$ on Mar. 4, 1910. Predicted maximum, June 17, 1909; minimum, Jan. 25, 1910.

T Cephei. Eleven observations, July 4, 1909, to April 2, 1910, give a well determined maximum of $6^{M}.5$ on Aug. 9, and an approximate minimum of $10^{M}.4$ on Jan. 11. Predicted maximum, July 29, 1909; minimum, Jan. 24, 1910.

V Coronae. Eight observations extend from Aug. 8, 1909, to Dec. 6, and give a well determined minimum of $12^{M}.4$ on Oct. 12. Predicted minimum, Sept. 20.

R T Cygni. Thirteen observations extend from July 4, 1909, to Feb. 10, 1910. Maximum on July 14, $7^{M}.2$, minimum on Oct. 24, $11^{M}.1$; maximum, about Jan. 9, 1910, $7^{M}.2$. Predicted dates, maximum on July 27, 1909; minimum, Nov. 6; maximum, Feb. 2, 1910.

Z Cygni. Fifteen observations from July 1, 1909, to Feb. 10, 1910, indicate a maximum of $8^{M}.8$ on or before July 9, 1909, the predicted date. A well determined minimum occurred on Nov. 19 at a magnitude <13. Predicted minimum, Nov. 24. The last observation on Feb. 10 gave a magnitude of $9^{M}.0$.

S Delphini. Six observations from Oct. 9 to Dec. 6, 1909, are all on the upward slope of the curve, $11^{M}.0$ to $9^{M}.5$. The minimum must have occurred not far from the predicted time.

U Herculis. Six observations, July 22 to Nov. 1, 1909, give a maximum of $8^{M}.4$ on Sept. 28. Predicted maximum Oct. 3.

S Lacertae. Nine observations from Aug. 10, to Dec. 8, 1909, give a well determined maximum of $8^{M}.0$ on Sept. 23, 1909. Predicted date, Sept. 3.

RY Lyrae. Five observations from Oct. 7, to Dec. 6, 1909, give a maximum of $9^{M}.8$ on Oct. 25. Predicted date, Oct. 27.

U Orionis. Ten observations, Dec. 8, 1909, to April 22, 1910, give a well determined minimum on Jan. 6, of $12^{M}.1$. Predicted minimum, Mar. 1, 1910.

V Orionis. Seven observations from Jan. 12 to April 2, 1910, indicate a maximum of $9^{M}.4$ about Jan. 25. Predicted maximum, Feb. 17. The final observation on April 9 has a magnitude of $12^{M}.3$.

R Pegasi. Ten observations extending from Oct. 6, 1909, to Jan. 8, 1910, give a maximum, $7^{M}.6$ about Oct. 17. Predicted maximum, Nov. 9.

S Pegasi. Ten observations all lie on the upward branch of the curve, from $13^{M}.1$, on Oct. 8, 1909, to $10^{M}.2$, on Feb. 10. Predicted minimum, Oct. 2, 1909; maximum, Feb. 13, 1910.

T Pegasi. Six observations all on the upward branch of the curve give the following magnitudes:— invisible in 12-inch (<14) on Oct. 8, 1909, to $11^{M}.8$, on Jan. 7, 1910. There is thus decided disagreement with the predicted values which assign a maximum on Oct. 22.

Z Pegasi. Eleven observations extending from Oct. 6, 1909, to Jan. 8, 1910, give a well determined maximum on Nov. 7. Predicted date, Nov. 18.

RV Pegasi. Four observations extending from Oct. 8, 1909, to Jan. 7, 1910, indicate a maximum of $8^{M}.8$ between Nov. 6 and Nov. 29, on both of which dates it was $8^{M}.9$. Predicted maximum, Dec. 22, 1909.

W Pegasi. Thirteen observations extending from Aug. 13, 1909, to Jan. 7, 1910, give a well determined maximum on Nov. 1, 1909. Predicted date, Nov. 11.

R Persei. Nine observations from Dec. 8, 1909, to Mar. 23, 1910, give a maximum on Feb. 9, of $8^{M}.4$. Predicted date, Feb. 15.

U Persei. Nine observations from Dec. 4, 1909, to April 23, 1910, give a well determined maximum on Jan. 6. Predicted maximum, Dec. 21, 1909.

R Serpentis. Nine observations extending from July 4, 1909, to Nov. 3, all on the downward slope of the curve show that the maximum must have occurred before the predicted date, July 22. The observed magnitudes are $8^{M}.0$ on July 4, $12^{M}.4$ on Nov. 3.

R Tauri. Ten observations extending from Jan. 28, 1909, to April 24, give a minimum of $13^{M}.8$ near Feb. 14, 1909. Predicted minimum, Feb. 9. A minimum also occurred between Dec. 4, 1909 and Jan. 8, 1910. Eleven observations from Dec. 4, 1909, to April 22, indicate a maximum of $8^{M}.0$ on April 9. Predicted date, May 20.

S Tauri. Nine observations extend from Jan. 28, 1909, to April 24, from magnitude $13^{M}.1$ to $10^{M}.0$, all on the upward slope of the curve. Predicted *maximum*, Feb. 12, 1909 (?). Ten observations from Dec. 4, 1909, to April 22, 1910, indicate a minimum of $14^{M}.0$, or less, between Dec. 4 and Feb. 12. Predicted *maximum*, Feb. 12, 1910.

RS Ursae Majoris. Eighteen observations extending from April 9, 1909, to April 16, 1910, give a well determined maximum of $8^{M}.4$ on July 6, 1909, and a minimum of <14 on Nov. 30, 1909. Predicted maximum, Aug. 1, 1909. Minimum, unknown.

Vassar College Observatory, 1910 *May* 4.

EPHEMERIS OF HALLEY'S COMET,

By F. E. SEAGRAVE.

The following ephemeris of Halley's comet is for Greenwich midnight on the respective dates, and is divided into two sections: June 1st to Sept. 25th and Oct. 23d to Dec. 6th, 1910.

1910	R.A.	Decl.	log r	log Δ
	h m s	° ′ ″		
June 1	9 55 59	+ 2 1 16	0.0243	9.7190
5	10 11 6	+ 0 37 59	0.0494	9.8308
9	10 20 47	− 0 14 16	0.0727	9.9182
13	10 27 52	− 0 53 15	0.0948	9.9906
17	10 33 27	− 1 24 26	0.1158	0.0518
21	10 38 8	− 1 51 5	0.1358	0.1047
25	10 42 14	− 2 14 46	0.1547	0.1508
29	10 45 56	− 2 36 47	0.1728	0.1919
July 3	10 49 24	− 2 57 48	0.1899	0.2286
7	10 52 11	− 3 18 12	0.2063	0.2617
11	10 55 50	− 3 38 14	0.2218	0.2916
15	10 58 53	− 3 58 16	0.2369	0.3190
19	11 1 51	− 4 18 18	0.2513	0.3441
23	11 4 46	− 4 38 22	0.2650	0.3671
27	11 7 39	− 4 58 32	0.2782	0.3881
31	11 10 27	5 19 2	0.2910	0.4078
Aug. 4	11 13 17	− 5 39 32	0.3032	0.4257
8	11 16 2	− 6 0 26	0.3150	0.4424
12	11 18 47	− 6 21 31	0.3264	0.4578
16	11 21 30	− 6 42 53	0.3373	0.4720
Aug. 20	11 24 9	− 7 4 22	0.3480	0.4852
24	11 26 46	− 7 26 13	0.3583	0.4974
28	11 29 24	− 7 48 10	0.3682	0.5086
Sept. 1	11 31 57	− 8 10 19	0.3778	0.5189
5	11 34 26	− 8 32 40	0.3874	0.5285
9	11 36 54	− 8 55 9	0.3964	0.5372
13	11 39 18	− 9 17 51	0.4053	0.5452
17	11 41 38	− 9 40 37	0.4139	0.5521
21	11 43 56	−10 3 32	0.4223	0.5589
25	11 46 11	−10 26 28	0.4304	0.5648

Too near the Sun in the morning sky for observation.

1910	R.A.	Decl.	log r	log Δ
Oct. 23	11 59 2	−13 7 1	0.4823	0.5894
27	12 0 24	−13 29 34	0.4890	0.5908
31	12 1 38	−13 51 48	0.4956	0.5916
Nov. 4	12 2 44	−14 13 54	0.5020	0.5920
8	12 3 37	−14 35 36	0.5083	0.5920
12	12 4 23	−14 57 23	0.5144	0.5914
16	12 4 54	−15 17 41	0.5206	0.5906
20	12 5 15	−15 38 12	0.5264	0.5892
24	12 5 22	−15 57 56	0.5323	0.5876
28	12 5 14	−16 16 55	0.5380	0.5856
Dec. 2	12 4 54	−16 35 23	0.5435	0.5832
6	12 4 16	−16 52 41	0.5490	0.5806

SUNSPOT OBSERVATIONS,

MADE AT BERWYN, PENN., WITH A 4½-INCH REFRACTOR,

BY A. W. QUIMBY.

1908	Time	New	Total		Fac.	Def.
		Grs.	Grs.	Spots	Grs.	
July 1	6	–	3	6	2	poor
2	6	–	3	6	2	“
3	10	2	3	16	2	fair
4	10	2	7	11	3	poor
5	6	–	6	13	4	fair
6	6	–	5	12	3	“
7	6	1	4	12	4	“
8	6	–	2	3	4	“
9	6	–	1	1	3	“
10	6	–	1	3	1	“
11	6	–	1	3	1	“
12	6	–	1	3	1	“
13	6	–	–	–	2	“
14	10	1	1	3	3	“
15	6	1	2	17	3	“
16	5	2	4	8	4	good
17	6	2	6	24	3	“
18	6	–	6	18	3	“
19	6	1	4	14	3	“
20	5	–	3	22	1	“
21	6	2	5	44	1	“
22	10	1	5	20	1	poor
23	6	–	5	22	3	“
24	7	–	5	10	4	“
25	6	–	2	2	3	“
26	8	–	1	1	–	“
27	6	–	1	1	1	fair
28	6	–	1	1	1	“
29	7	–	1	1	1	“
30	6	1	2	4	2	“
31	6	1	3	6	3	“
Aug. 1	5	1	4	36	2	“
2	6	–	4	45	3	“
3	6	–	3	60	2	good
4	6	1	4	67	1	“
5	6	–	4	60	–	“
6	7	–	4	96	–	fair
7	7	–	4	90	–	“
8	7	1	5	81	2	“
9	5	–	4	56	4	“
10	6	–	4	46	4	“
11	6	–	3	20	2	“
12	11	–	2	7	1	poor
13	6	2	4	15	2	fair
14	6	3	6	34	3	“
15	6	–	6	31	3	“
16	7	–	6	26	3	“
17	7	–	5	30	2	poor
18	6	–	4	36	3	fair
19	6	–	4	54	3	good
20	6	–	3	31	2	fair
21	7	1	4	21	2	poor
22	3	–	2	18	3	“
23	5	–	2	12	2	“
24	5	1	3	11	2	“
25	9	–	2	6	1	“
27	1	1	2	18	–	“
28	7	4	7	74	4	fair
29	6	–	6	60	4	“
30	6	2	7	136	3	good
Aug. 31	6	–	6	93	3	fair
Sept. 1	6	–	6	110	2	good
2	5	1	5	86	2	fair
3	6	–	5	92	2	“
4	7	–	5	73	3	“
5	7	1	6	22	3	poor
6	5	2	6	25	3	“
7	7	–	6	35	3	“
8	7	–	5	35	3	“
9	7	–	4	36	3	“
10	7	1	4	46	1	poor
11	7	–	4	38	1	“
12	7	–	4	40	1	good
13	7	–	4	16	2	poor
14	7	1	5	15	3	fair
15	7	–	4	13	2	“
16	7	–	3	10	2	“
17	4	1	4	16	3	poor
18	7	1	5	18	3	“
19	7	1	6	23	3	fair
20	7	–	5	18	3	poor
21	7	–	4	18	3	“
22	7	1	5	26	3	fair
23	7	–	4	35	3	“
24	7	–	4	38	2	“
25	7	–	4	35	3	“
26	2	–	3	28	1	poor
27	4	1	4	40	3	fair
28	12	–	3	22	–	poor
29	7	–	3	18	2	fair
30	7	2	5	14	3	“
Oct. 1	7	–	4	11	2	poor
2	7	1	5	13	3	fair
3	7	–	4	8	1	poor
4	7	–	4	8	2	fair
5	7	1	5	8	1	“
6	7	–	4	10	1	“
7	2	1	4	5	1	“
8	11	–	4	4	2	“
9	9	–	3	5	2	“
10	8	–	2	2	–	poor
11	7	1	4	10	2	fair
12	7	–	3	6	2	“
13	7	–	2	3	2	“
14	7	–	1	1	1	“
15	7	–	–	–	2	“
16	7	–	–	–	2	“
17	7	–	–	–	3	“
18	7	–	–	–	2	“
19	7	–	–	–	2	“
20	8	1	1	1	2	“
21	8	–	1	2	1	“
22	10	–	1	3	1	“
23	9	–	1	1	–	poor
24	10	–	1	1	–	“
25	11	–	1	1	1	“
26	10	–	1	3	–	“
27	11	1	2	3	3	fair
29	8	–	1	1	3	“
Oct. 30	8	1	2	2	3	fair
31	8	–	1	1	1	“
Nov. 1	8	–	1	1	2	“
2	8	1	2	2	1	“
3	8	–	2	2	1	“
4	8	–	2	2	1	“
5	8	–	2	2	1	“
6	11	1	4	9	2	“
7	9	–	4	13	2	“
8	8	–	3	17	1	“
9	8	1	4	28	2	“
10	8	–	4	26	–	poor
11	3	–	4	18	1	“
12	8	1	5	35	4	fair
13	8	1	5	25	3	“
14	9	–	2	12	–	poor
15	8	1	5	30	3	fair
16	8	–	5	22	2	“
17	8	–	5	21	3	“
18	12	–	2	26	–	poor
19	8	–	2	30	–	fair
20	8	–	2	10	–	“
21	8	–	2	7	1	“
22	8	1	3	8	2	“
23	10	–	3	5	1	poor
24	10	1	4	7	2	fair
25	11	–	3	3	2	poor
26	2	–	2	6	1	“
27	8	–	1	5	2	fair
28	8	–	1	3	1	poor
29	8	–	1	5	–	fair
30	4	1	2	4	1	poor
Dec. 1	10	–	2	2	1	“
2	8	1	3	5	1	fair
3	8	1	4	6	3	“
4	8	–	2	5	1	poor
5	2	–	2	5	1	fair
6	8	–	2	5	–	“
7	3	–	2	4	–	“
8	8	–	2	8	–	good
9	9	1	3	3	1	fair
10	8	2	4	6	3	good
12	8	–	3	4	1	poor
13	3	1	3	4	2	fair
14	2	–	3	4	2	“
15	8	–	1	1	1	“
16	8	–	–	–	1	“
18	3	2	2	7	–	“
19	8	–	2	7	1	“
20	8	1	3	8	2	poor
21	8	–	2	7	–	“
23	8	2	4	21	2	fair
25	9	–	3	35	1	“
26	8	–	3	20	1	“
27	8	1	3	9	1	“
28	8	1	4	9	2	“
29	8	1	5	17	3	“
30	10	–	2	3	1	v poor
31	8	–	3	26	2	fair

SUNSPOT OBSERVATIONS,

MADE AT BERWYN, PENN., WITH A 4½-INCH REFRACTOR,

By A. W. QUIMBY.

1909	Time	New Grs.	Total Grs.	Total Spots	Fac. Grs.	Def.
Jan. 1	9	–	3	20	–	fair
2	9	–	3	20	1	"
3	2	–	2	16	1	"
4	8	–	2	5	–	poor
6	9	–	2	9	–	"
8	9	3	5	11	2	fair
9	10	1	5	11	3	poor
11	8	–	2	2	–	"
12	1	–	2	3	–	"
13	8	–	2	4	–	fair
15	10	2	3	5	1	poor
17	4	2	5	7	–	"
18	8	–	4	11	1	fair
19	8	–	3	11	–	"
20	8	–	2	7	–	"
21	8	–	2	8	–	"
22	8	2	4	9	2	"
23	9	–	2	2	–	poor
24	9	2	6	14	3	"
25	8	–	6	22	4	fair
26	8	–	5	22	4	poor
27	8	1	6	47	3	fair
28	8	–	5	46	2	"
29	9	–	3	10	–	v poor
30	8	–	5	27	–	fair
31	10	–	5	28	–	"
Feb. 1	9	–	5	22	–	poor
2	8	–	5	22	2	fair
4	3	–	3	4	2	"
5	8	–	2	2	1	"
6	8	–	2	2	3	"
7	8	–	1	1	1	"
8	8	–	1	1	1	"
10	4	1	1	1	1	"
11	8	1	2	2	1	"
12	9	2	4	11	2	"
13	2	–	4	16	1	"
14	10	–	3	10	–	poor
15	4	–	2	11	–	fair
16	10	–	2	16	–	"
17	8	–	2	15	–	"
18	8	–	2	9	–	"
19	8	–	2	7	4	"
20	8	1	3	6	3	"
21	2		3	5	3	"
22	2	–	3	4	2	"
23	8	1	3	6	3	"
25	8	2	3	23	1	"
26	8	1	4	30	2	"
27	8		4	33	1	"
28	8	–	4	43	–	good
Mar. 1	8		4	49	2	"
2	12	–	4	30	1	poor
3	8	–	4	38	3	fair
4	12	–	3	10	–	poor
5	8	1	4	22	3	fair
Mar. 6	8	–	4	15	2	fair
7	3	–	3	3	2	good
8	8	–	1	1	1	fair
10	4	1	1	1	1	"
11	5	–	1	3	2	"
12	8	1	2	7	2	good
14	9	–	1	3	–	poor
15	8	–	1	1	1	fair
16	8	–	1	1	1	"
17	8	1	2	4	1	"
18	8		2	7	1	"
19	8	2	3	6	2	"
20	8	1	4	16	2	"
21	8	1	4	16	2	"
22	8	1	5	20	3	"
23	7	2	7	36	2	"
24	7	–	7	70	2	good
25	1	0	3	20		poor
26	7	–	6	22	1	fair
27	7	–	5	33	–	"
28	12	1	5	13	–	poor
29	7	2	7	40	4	fair
30	7	1	8	47	5	"
31	7	–	4	22	–	"
Apr. 1	7	–	3	15	1	"
2	7		3	27	3	"
3	5	–	2	13	–	"
4	7	–	2	13		"
5	7		2	13	–	"
6	5	–	2	6	–	poor
7	7	–	2	8	2	fair
8	7	–	2	5	2	poor
9	9	–	1	1	1	"
10	7	–	–		1	fair
11	7	1	1	2	–	"
12	7	–	1	2	–	"
13	7	–	1	2	1	"
15	5	1	2	3	4	good
16	5	1	3	8	4	"
17	7	1	4	8	4	"
18	7	1	4	6	3	fair
19	7	1	4	13	2	"
22	7	–	4	26	–	fair
23	1	–	2	13	–	"
24	7	–	2	11		"
25	7	–	2	8	1	"
26	7	–	2	9	2	"
27	2		2	6	1	"
28	6	–	2	1	1	poor
29	11	–	1	1	–	"
30	12	–	1	1		"
May 1	2		1	3		"
2	7	1	2	13	–	fair
3	7	–	2	13	1	"
4	7	–	2	6	1	"
May 5	5	2	3	4	3	fair
6	5	1	3	4	3	"
7	6	–	3	8	2	"
8	6		2	27	1	good
9	5	–	2	35	1	"
10	7	–	2	32	1	fair
11	7	–	2	35	1	good
12	7	–	2	25	1	fair
13	7	–	2	25	–	"
14	5		2	40	1	good
15	7		2	45	3	"
16	7	–	2	27	2	fair
17	7		1	13	1	"
18	7	2	3	11	2	"
19	7	–	3	11	1	poor
20	7	–	2	5	1	fair
21	11	–	–	–	–	v poor
23	8	1	2	13	2	fair
24	7	–	2	12	2	"
25	6	–	2	8	2	"
26	6	–	2	3	1	poor
27	5	–	2	4	1	fair
28	6		2	3	1	"
29	7		2	3	1	"
30	6	–	1	1	1	"
31	6	–	1	1	1	"
June 1	6	–	1	1	1	"
2	5	–			1	"
3	5	1	1	1	1	"
4	5	–	1	1	–	poor
5	2	1	2	3	–	"
6	7	1	3	20	2	good
7	6	–	2	14	1	fair
8	6	–	2	5	1	poor
10	11	–	1	3	–	"
11	10	–	1	3	–	"
12	6	–	1	3	2	fair
13	7	–	1	1	–	poor
14	7	1	2	3	1	fair
15	6	1	3	7	–	poor
16	6	1	4	14	1	fair
17	6	–	3	17	2	"
18	6	–	3	19	1	"
19	6	–	2	7	2	"
20	6		1	3	1	"
21	6	1	2	4	2	"
22	6	–	2	9	2	"
23	6	–	1	7	1	"
24	6	–	1	6	1	"
25	6	1	2	5	1	"
26	6	1	3	4	1	"
27	7	–	3	5	1	"
28	11	–	1	2	–	poor
29	6	–	2	1	1	fair
30	6	–	1	1	2	"

SUNSPOT OBSERVATIONS,

MADE AT BERWYN, PENN., WITH A 4½-INCH REFRACTOR,

By A. W. QUIMBY.

1909	Time	New Grs.	Total Grs.	Total Spots	Fac. Grs.	Def.
July 1	6	–	1	1	1	fair
2	6	–	1	1	1	poor
3	6	–	1	1	–	fair
4	6	–	1	1	–	“
5	6	–	1	1	2	“
6	6	1	2	3	3	“
7	5	1	2	5	2	“
8	6	–	1	3	2	“
9	6	–	1	3	4	“
10	6	–	1	1	2	“
11	5	–	1	1	3	“
12	6	–	1	1	2	“
13	6	1	2	7	2	“
14	5	–	2	7	1	“
15	6	1	2	4	1	“
16	6	–	2	11	1	“
17	6	–	2	11	2	“
18	6	1	3	12	3	“
19	6	2	5	19	2	“
20	6	–	4	25	3	“
21	6	–	4	25	1	“
22	9	–	4	25	1	“
23	2	1	4	26	1	“
24	4	–	4	40	1	v good
25	7	–	4	38	1	fair
26	7	–	4	30	1	“
27	7	–	3	12	2	“
28	7	–	2	10	3	“
29	7	–	2	4	1	“
30	7	–	2	3	3	“
31	7	2	3	6	1	“
Aug. 1	7	–	3	9	2	good
2	7	–	3	9	2	fair
3	7	–	3	6	2	“
4	1	–	2	8	2	poor
5	7	–	1	4	–	“
6	6	–	1	8	–	“
7	8	–	1	4	–	“
8	6	–	1	7	1	“
9	6	–	–	–	1	“
10	6	1	1	6	3	fair
11	7	–	1	3	2	“
12	6	–	1	2	2	“
13	6	1	2	4	1	“
14	7	1	3	4	2	“
15	7	2	4	7	3	“
18	7	–	2	7	1	poor
19	7	–	2	5	1	fair
20	6	–	2	2	1	“
21	6	–	2	3	2	“
22	6	1	2	3	1	“
23	6	1	2	3	1	“
24	6	1	2	5	2	“
25	7	–	1	5	3	“
26	7	1	2	5	2	“
27	7	–	1	2	2	“
28	7	–	–	–	2	“
29	7	2	2	3	2	“
30	7	–	2	5	–	“
Aug. 31	7	1	2	3	1	fair
Sept. 1	8	–	1	7	1	“
2	7	–	1	8	3	“
3	7	–	1	7	1	“
4	6	1	2	9	–	“
5	5	–	2	13	1	v good
6	7	–	2	18	1	“
7	7	–	1	17	1	fair
8	6	–	1	41	–	v good
9	7	–	1	41	1	good
11	7	–	1	36	2	fair
12	7	1	2	29	1	“
13	7	–	2	14	1	“
14	5	–	2	3	2	poor
15	10	–	1	2	–	“
16	8	1	2	7	1	fair
17	7	–	1	4	2	“
18	7	1	2	4	2	“
19	7	–	2	9	2	“
20	4	–	1	8	1	poor
21	7	1	2	10	–	“
22	4	–	2	12	–	“
23	3	–	2	18	2	fair
24	5	1	3	14	1	poor
25	7	0	2	13	2	fair
26	7	0	2	12	1	“
27	7	–	2	10	2	“
28	8	3	5	14	3	“
29	7	–	4	11	2	“
30	7	–	3	11	2	“
Oct. 1	7	–	3	7	1	“
2	7	2	5	17	1	“
3	1	–	3	7	–	poor
4	8	–	4	10	–	“
5	7	3	7	22	2	good
6	7	–	6	21	3	fair
7	7	1	6	22	2	“
8	7	–	5	42	4	“
9	7	–	5	60	4	“
10	7	–	4	62	2	“
11	7	–	4	65	2	“
12	7	1	4	65	2	“
13	7	1	5	70	3	“
14	7	1	6	45	3	poor
15	7	–	5	40	3	“
16	7	–	4	23	3	fair
17	7	–	3	17	3	“
18	4	–	3	10	2	poor
19	7	7	2	11	3	good
20	7	–	1	5	2	poor
21	7	1	2	3	1	“
22	7	–	2	3	3	fair
23	7	–	1	1	–	poor
24	9	1	2	3	–	“
25	9	1	3	7	2	fair
26	7	1	3	8	3	“
27	7	–	3	8	2	“
28	7	–	3	8	1	“
29	7	–	2	2	–	“
Oct. 30	7	1	4	10	–	fair
31	8	1	5	10	1	“
Nov. 1	8	1	4	17	2	“
2	8	–	4	20	–	poor
3	8	1	4	14	2	fair
4	8	–	4	18	4	“
5	8	2	6	25	3	“
6	8	1	7	37	3	fair
7	8	–	5	18	2	poor
8	10	–	5	16	1	fair
9	11	–	3	3	–	v poor
10	8	–	2	3	1	fair
11	8	1	2	3	2	“
12	8	1	1	7	3	“
13	8	–	2	10	3	“
15	8	–	2	4	1	“
16	8	1	3	8	1	“
17	10	–	2	8	–	poor
18	8	–	2	11	–	fair
19	8	–	2	7	–	poor
20	8	1	3	9	2	fair
21	8	1	4	9	3	“
22	8	1	5	17	4	“
23	8	–	3	10	2	poor
25	2	–	4	19	1	fair
26	8	–	4	30	1	“
27	8	1	4	36	2	“
28	8	1	5	59	2	good
29	8	1	6	43	2	fair
30	9	–	6	42	2	“
Dec. 1	8	–	6	33	3	“
2	8	–	6	26	2	poor
3	8	–	5	16	2	“
4	8	–	2	19	1	fair
5	8	–	2	18	1	“
6	8	–	1	9	1	poor
7	8	–	1	1	–	v poor
8	9	–	1	3	–	poor
9	8	–	1	5	1	good
10	8	–	1	3	1	“
11	8	–	–	–	1	fair
12	8	–	–	–	–	v poor
14	8	1	1	4	–	fair
15	10	–	1	10	–	poor
16	10	–	1	8	–	“
17	8	1	2	19	1	fair
18	8	1	3	20	2	“
19	8	2	5	15	1	“
20	8	1	6	19	–	“
21	8	–	6	14	–	“
22	8	1	7	18	1	“
23	8	–	7	10	3	poor
24	8	–	6	9	3	“
26	1	–	4	7	1	“
27	9	–	5	5	1	“
28	8	3	8	14	3	fair
29	2	–	4	8	2	poor
30	8	2	8	18	2	fair
31	2	–	3	8	1	“

OBSERVATIONS OF COMETS,

MADE WITH THE 16-INCH REFRACTOR OF GOODSELL OBSERVATORY,

BY H. C. WILSON AND C. H. GINGRICH.

1910 Local M.T.	Δα	Δδ	Comp.	App. α	App. δ	log. pΔ		*
			HALLEY'S COMET.					
h m s	m s	′ ″		h m s	° ′ ″			
Jan. 29 9 23 46	−0 36.18	+0 23.5	9 , 6	1 6 53.00	+ 8 28 38.8	9.607	0.763	5*
29 9 23 46	−2 5.55	−1 10.6	9 , 6	1 6 53.02	+ 8 28 36.2	9.607	0.763	6*
Feb. 1 7 42 9	+0 27.62	−3 22.2	12 , 6	1 2 26.61	+ 8 19 42.0	9.518	0.750	4*
3 7 48 56	+0 52.42	−3 45.6	9 , 6	0 59 37.04	+ 8 14 33.0	9.544	0.745	3*
17 8 1 28	−1 11.77	+2 59.9	12 , 6	0 43 43.24	+ 7 54 59.5	9.614	0.769	2†
18 7 25 10	+0 36.00	+5 42.9	12 , 6	0 42 48.32	+ 7 54 34.1	9.596	0.760	1†
			DANIEL'S COMET.					
Feb. 1 8 58 20	−0 9.00	....	8 , 0	6 34 39.29	....	.....	......	7*
1 8 58 20	−0 20.52	−1 58.6	9 , 6	6 34 39.33	+56 36 10.7	n9.599	n0.244	8*
2 10 11 18	+1 11.23	....	12 , 0	6 35 59.49	....	.....	.....	7*
2 10 11 18	+0 59.63	−4 1.9	12 , 6	6 35 59.45	+56 34 7.6	8.901	n0.265	8*

Mean Places for 1910.0 of Comparison Stars.

*	α	Red to App.	δ	Red to App.	Authority
	h m s	s	° ′ ″	″	
1	0 42 13.75	−1.43	+ 7 48 58.3	− 7.1	BD +7°106 Toulouse phot.
2	0 44 56.42	−1.42	+ 7 52 6.5	− 6.9	BD +7°115 Toulouse phot.
3	0 58 45.86	−1.24	+ 8 18 24.4	− 5.8	BD +8°161 Toulouse phot.
4	1 2 0.19	−1.20	+ 8 23 9.7	− 5.5	BD +8°173 Toulouse phot.
5	1 7 30.20	−1.02	+ 8 28 20.3	− 5.0	BD +8°185 Toulouse phot.
6	1 8 59.59	−1.02	+ 8 29 51.8	− 5.0	BD +8°187 Toulouse phot.
7	6 34 47.17	+1.12	+56 39 42.5	+10.1	9^M.8 Microm. comp. with 9
		+1.09		+10.3	
8	6 34 58.73	+1.12	+56 37 59.2	+10.1	BD 56°1141 Microm. comp. with 7
		+1.09		+10.3	
9	6 35 14.87	+1.12	+56 46 41.2	+10.1	Greenwich 1890, No. 2039

* = H. C. WILSON. † = C. H. GINGRICH.

PHOTOMETRIC OBSERVATIONS OF STARS NEAR M 57,

BY KEIVIN BURNS.

At the request of Professor LEAVENWORTH, Director CAMPBELL of the Lick Observatory had the magnitudes of the stars in the field of the Ring Nebula in *Lyra* standardized and assigned the work to the writer. The Wedge Photometer, described by Mr. MADDRILL in *L. O. Bulletin* 3, 161, attached to the 12″ telescope, was used to make all the measures.

In connecting Standard Stars with Nos. 5, 6, 7, 27, 28, the aperture was reduced to 8 in. and two-thirds of the glass was covered by three sectors symmetrically arranged. Full aperture, 12 in., was used for the remaining observations. The light used was a 10v. lamp with carbon filament. In spite of the blue glass screen this gave a star much too red. In the course of the summer a Tungsten lamp was found to be more satisfactory in every way, but the work was finished as begun, with the carbon lamp, in order to have the whole piece of work as consistent as possible. It is possible that the apparent larger size of the artificial star when 12 in. aperture was used introduced a systematic error. The artificial star appeared larger than the real star when both were bright; and equal in size when equality in brightness was obtained with the scale set at a reading greater than 20. The plan used in observing was essentially that outlined by Mr. PARKHURST in "Researches in Stellar Photometry." Three settings of the wedge were made on each star and the process repeated, taking the stars in the reverse order. The measures were reduced by means of the table in Mr. MADDRILL's article, mentioned above. The magnitudes of the Standard Stars used are those of the Harvard Catalogues, *H.C.O. Annals*, 50 and 54. These catalogues contain one more star than the Potsdam Catalogue, and that a faint one, within easy reach of the Nebula, and my measures agree better with the Harvard values than with those of the Potsdam Catalogue. The latter makes the mean magnitude of this group of Standard Stars about two-tenths greater than the Harvard.

STANDARD CATALOGUE STARS.

Star	B.D. No.	α 1900	δ 1900	H.C.O. Mag.	Meas. Mag.	p.e.
		h m s	° ′			
A	+33°3215	18 45 44	+33 35.1	6.89	6.90	±.02
B	32°3226	46 2	32 51.8	8.90	8.90	.01
C	32°3227	46 3	32 41.8	5.77	5.76	.03
D	33°3257	51 13	33 50.5	6.08	6.00	. . .
E	32°3253	18 51 29	+32 28.3	7.48	7.52	±.02

TABLE OF STARS OBSERVED.

No.	R.A. 1900	Decl. 1900	H. Mag.	Obs. Mag.	p.e. unit M.01	No. Obs.
	h m s	° ′				
1	18 49 8	+33 2.8		10.60	± 5	4
2	49 11	32 46.1		11.89	7	3
3	49 15	32 46.9		11.79	7	3
4	49 20	33 2.7		11.08	3	3
5	49 21	32 48.1		10.01	5	3
6	49 21	33 0.2		9.93	7	3
7	49 26	33 5.2		8.42	7	4
8	49 29	32 55.8		10.68	5	4
9	49 29	32 49.9		12.14	4	3
10	49 32	32 54.3		11.87	4	3
11	49 32	33 4.8		10.75	5	3
12	49 34	32 50.9		11.10	3	4
13	49 36	32 55.4		12.34	10	3
14	49 43	32 50.4		12.68	7	3
15	49 52	32 58.3		11.89	7	3
16 *k*	49 52	32 41.2	12.78	12.01	8	4
17 *c*	49 53	32 48.9	11.09	10.77	2	4
18 *g*	49 56	32 44.3	12.30	11.47	7	4
19	49 57	32 54.2		12.39	11	3
20	50 6	32 49.6		12.62	8	3
21 *b*	50 6	32 44.2	10.94	10.84	3	4
22 *a*	50 13	32 39.9	10.84	10.54	4	4
23 *d*	50 21	32 45.8	11.34	10.79	5	4
24 *f*	18 50 24	+32 40.9	11.88	11.58	±10	4
25 *l*	18 50 26	+32 41.2	12.97	12.47	± 7	4
26 *h*	50 28	32 43.3	12.51	11.90	7	4
27	50 54	32 58.1		8.46	3	4
28	18 50 57	+32 48.0		9.57	± 5	4

Stars 7 and 27, are A.G. Leiden 6939 and 6955 respectively. The letters are those used in *H. C. O. Annals*, Vol. 57, 2, Comparison Stars for 185032 *RX Lyrae*, from which publication the values in the column headed "H mag." are taken. Neither star 13 nor 21, which the photographic plate shows to be double, appeared double in the Photometer.

It is a pleasure to thank Director CAMPBELL for his helpful suggestions and interest in this work. Special acknowledgement is due Astronomer AITKEN, who taught the writer the use of the photometer. Director E. C. PICKERING kindly furnished the catalogues and a chart of the region of *RX Lyrae*.

The greater part of the work of reducing the observations was done at the University of Minnesota; the observations were, of course, all made at Mount Hamilton.

University of Minnesota, Minn., 1910 *March* 7.

EPHEMERIS OF COMET *a* 1910.

BY R. H. CURTISS.

Gr. M.Midnight	α	δ	log Δ	log r
1910	h m s	° ′ ″		
May 27.5	22 31 37.6	+29 31 34	0.44086	0.43240
31.5	22 28 38.2	30 8 15	0.44024	
June 4.5	22 25 11.8	30 42 51	0.43951	
8.5	22 21 17.7	31 15 10	0.43874	
12.5	22 16 58.0	31 44 50	0.43799	0.46728
16.5	22 12 11.0	32 11 18	0.43731	
20.5	22 6 58.4	32 34 15	0.43678	
24.5	22 1 20.6	32 53 14	0.43649	
28.5	21 55 20.7	33 7 59	0.43644	0.49850
July 2.5	21 48 59.8	33 18 6	0.43672	
6.5	21 42 20.7	33 23 6	0.43740	
10.5	21 35 27.1	33 22 44	0.43856	
14.5	21 28 23.0	33 16 44	0.44027	0.52668
18.5	21 21 12.1	33 5 3	0.44255	
22.5	21 13 58.9	32 47 54	0.44540	
26.5	21 6 48.5	32 25 10	0.44887	
30.5	20 59 44.7	+31 57 7	0.45307	0.55240

Detroit Observatory, University of Michigan, 1910 *May* 4.

OBSERVATIONS OF HALLEY'S COMET.

MADE WITH THE 26-INCH EQUATORIAL AT THE U.S. NAVAL OBSERVATORY

BY J. B. EPPES.

[Communicated by Captain T. E. DE WITT VEEDER, U.S. Navy, Superintendent.]

1910 Wash. M.T.	*	Comp.	Δα	Δδ	App. α	App. δ	log pΔ		Red. to App. Pl.	
h m s			m s	″	h m s	° ′ ″			s	″
Mar. 3 7 26 33	1	10 , 2	−1 43.34	− 3 25.5	0 31 57.99	+ 7 54 58.2	9.662	0.729	−1.55	−8.2
4 7 13 24	2	20 , 4	+3 16.11	+ 8 11.2	0 31 12.27	7 55 23.7	9.660	0.726	−1.56	−8.4
Apr. 9 16 56 27	3	15 , 5	+2 9.17	− 2 53.8	0 0 1.64	7 56 5.7	9.664*n*	0.734	−1.36	−9.4
10 17 2 16	3	15 , 5	+1 11.64	− 4 1.6	23 59 4.13	7 54 57.9	9.663*n*	0.730	−1.34	−9.4
13 16 36 18	3	15 , 5	−1 31.91	− 7 20.8	23 56 20.64	7 51 39.0	9.664*n*	0.734	−1.28	−9.1
13 16 57 10	3	15 , 5	−1 32.73	− 7 22.2	23 56 19.82	7 51 37.6	9.661*n*	0.727	−1.28	−9.1
19 16 16 28	4	21 , 7	+0 54.53	+ 3 26.7	23 51 54.90	7 46 38.8	9.663*n*	0.731	−1.15	−8.8
19 16 50 34	4	15 , 5	+0 53.82	+ 3 25.9	23 51 54.19	+ 7 46 38.0	9.654*n*	0.720	−1.15	−8.8

Mean Places of Comparison-Stars for the beginning of the Year.

*	α	δ	Authority	*	α	δ	Authority
	h m s	° ′ ″			h m s	° ′ ″	
1	0 33 42.88	+ 7 58 31.9	A.G. Leipzig II. 197	3	23 57 53.83	+ 7 59 8.9	A.G. Leipzig II. 11861
2	0 27 57.72	+ 7 47 20.9	A.G. Leipzig II, 161	4	23 51 1.52	+ 7 43 20.9	A.G. Leipzig II. 11818

NOTES.

April 9. No tail.

April 13. Comet is brightening very rapidly, jets formed, tail forming.

April 19. Comet much brighter, is visible to the naked eye. In the telescope the tail can be traced with certainty for 5′. Measures with the micrometer give the diameter of the head 7″, the distance from head to extremity of jets (towards sun) 14″.

ORBIT OF MINOR PLANET, 1909 HF,

BY JOHN M. POOR.

The following elements of this planet are derived from the observations made by PECHÜLE at Copenhagen, 1909, August 21, September 1, and September 12. They were published in *A.N.*, 4354 and 4358.

ELEMENTS OF 1909 H F. (1909 Sept. 1.5 Berlin M.T.)

$$\begin{aligned} M &= 0^\circ\ 35'\ 58''.4 \\ \omega &= 85\ 24\ 18.5 \\ \Omega &= 244\ 4\ 39.7 \\ i &= 15\ 43\ 50.1 \\ \phi &= 15\ 28\ 13.6 \end{aligned} \quad \left.\begin{matrix}\omega\\ \Omega\\ i\end{matrix}\right\} 1909.0 \qquad \begin{aligned} \log a &= 0.413\ 1077 \\ \mu &= 851''.8145 \end{aligned}$$

The rectangular coordinates referred to the equator and equinox of 1909.0 are given by the equations:

$$\begin{aligned} x &= [9.986\ 6894]\, r \sin (v + 58^\circ\ 36'\ 46''.2) \\ y &= [9.983\ 0101]\, r \sin (v + 324\ 29\ 58.9) \\ z &= [9.564\ 7080]\, r \sin (v + 8\ 11\ 48.5) \end{aligned}$$

Shattuck Observatory, Hanover, N.H., 1910 *April* 9.

OBSERVATIONS OF COMET *a* 1910,

BY F. P. LEAVENWORTH.

The positions were obtained from photographs taken with the $10\frac{1}{2}$-inch equatorial of the University of Minnesota. They are corrected for fixed-star aberration and are reduced to the equinox and equator of 1910.0.

1910 Minn. M.T.		α	δ	log pΔ		No. of stars
	h m s	h m s	° ′ ″			
Feb. 1	6 20 9	21 44 14.36	+5 1 35.0	9.617	0.785	6
6	6 25 41	21 48 16.99	6 1 13.8	9.620	0.786	4
7	6 24 0	21 49 55.16	+6 28 36.1	9.620	0.786	1

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PRECESSION AND SOLAR MOTION.

SECOND PAPER. SOLUTION OF THE EQUATIONS.

BY LEWIS BOSS.

The object of this paper is to show in a rather summary discussion, what results for the motion of the Equinox, the precession, and the coordinates of solar motion may fairly satisfy the observed quantities contained in Table I, presented in my previous paper (*A.J.*, 612), under the hypotheses described in connection therewith.

In order to assist judgment, as to sufficiency of the conclusions, it will be well to derive numerical results for the probable errors of the quantities determined. It is often objected that such probable errors may be misleading, especially when there is uncertainty in the validity of theoretical hypotheses underlying such investigations. This is true enough. Nothing can absolve the computer from the use of judgment in estimating the scope of such determinations of probable error. But, on the other hand, such determinations may be very useful in forming a judgment as to the reality of suspected and unsuspected sources of systematic error that probably exist. It may be of great importance to be able to form an opinion of the character and extent of unknown disturbing elements. On the other hand reasonableness in interpreting results is required. There are indications that computers sometimes seem to regard what is called the probable error as marking the limit beyond which errors ought not to be tolerated. Yet theory shows and experience teaches, that once in every five trials we may have a strictly casual residual that is twice the probable error. As to residuals that are three times the probable error, they should occur four or five times in 100 trials, as mere casual errors. These facts are elementary to be sure, but they should not be ignored in forming the judgment as to whether, in a given discussion, serious anomalies exist, owing to unknown sources of error.

In Table I (*A.J.*,612, p. 97) the absolute terms for both right-ascension and declination in 100 Trapeziums and sixteen half sectors near the two poles are given under the captions, $\mu \cos \delta$ and μ'. These are the direct means of the corresponding values for each star within the respective areas. In the actual computation, as carried out in forming the normal equations, two decimal places for these quantities were employed instead of one as given for them in Table I. Likewise, as already stated in *A.J.*, 612, the coefficients of Δk, Δn, X, Y, and Z, corresponding to the mean $\mu \cos \delta$ and μ' of the respective areas, are not those which would be computed from the mean α and δ of those areas, but are the means of the coefficients computed for each star within those areas.

The form of the conditional equations is given on page 95 of my previous article (*A.J.*, No. 612) in which the factor, $\frac{1}{\rho}$, usually associated with the coefficients of X, Y, and Z, is suppressed under the hypothesis that ρ, the mean distance of the stars in each area, could be taken, with sufficient approximation, equal to unity. To each conditional equation for each of the Trapeziums, weight unity is assigned, irrespective of the number of stars contained therein. The half-sectors from 101_1 to 108_2 received weight one-half. The latter contain, in the mean, only twenty stars each. It was necessary to make this division into half-areas, in order to get a good range in the values of $\sin \alpha$ and $\cos \alpha$, and a consequently greater weight of determination, especially for n, X, and Y. The normal equations were then formed in the usual manner. They are exhibited in Table II.

It will be seen in the set of normal equations, combining both those in right-ascension and declination, that the determinateness is almost complete. Each unknown is independent of every other. Thus the coordinates of the solar apex are independent of the adopted value of precession.

The General Solution, based upon the combination of both the right-ascension and declination equations, will be

TABLE II. NORMAL EQUATIONS (+90° TO −90°).

Δk	Δn	X	Y	Z	
		RIGHT-ASCENSION.			
70.65	−.05	+.11	−.11		= −26″.06
−.05	+17.14	+.35	+.17		= +5.92
+.11	+.35	+52.80	+.25		= +.71
−.11	+.17	+.25	+53.01		= −170.84
		DECLINATION.			
	53.01	−.41	−.17	−.11	= +17.60
	−.41	+18.02	+.06	−.30	= −.33
	−.17	+.06	+17.14	+.05	= −51.94
	−.11	−.30	+.05	+70.65	= +152.81
		COMBINED RIGHT-ASCENSION AND DECLINATION.			
70.65	−.05	+.11	−.11	.00	= −26.06
−.05	+70.15	−.06	.00	−.11	= +23.52
+.11	−.06	+70.82	+.31	−.30	= +.38
−.11	.00	+.31	+70.15	+.05	= −222.78
.00	−.11	−.30	+.05	+70.65	= +152.81

regarded for the time being to be definitive as to the observed values of the unknowns. By means of partial solutions in various forms we may then examine the real weight of determination in the General Solution; and we may ultimately be led to examine what changes may seem to be needed in our fundamental hypotheses.

We proceed to state the results of this which we will call the General Solution. We have:

$$\mu_0 = 5''.38 \quad ; \quad \text{Mean Magn.} = 5^{\text{M}}.7.$$

$$\Delta k = -''.37 \pm''.06 \text{ to } \pm''.08 \qquad X = +''.03 \pm''.06 \text{ to } \pm''.08$$

$$\Delta n = +.34 \pm .06 \text{ to } \pm .08 \qquad Y = -3.18 \pm .06 \text{ to } \pm .08$$

$$Z = +2.17 \pm .06 \text{ to } \pm .08$$

Putting M for the centennial parallactic drift at 90° from the solar apex; A for the right-ascension, and D for the declination of the solar apex at the Epoch, 1875, we have:

$$X = M \cos D \cos A$$
$$Y = M \cos D \sin A$$
$$Z = M \sin D$$

Solving these equations by means of the known values of X, Y and Z we have:

$$\mathbf{M = 3''.85 \pm''.06 \text{ to } \pm''.08}$$

$$\left.\begin{aligned} \mathbf{A} &= \mathbf{270^\circ.52 \pm 1^\circ.08 \text{ to } \pm 1^\circ.53} \\ \mathbf{D} &= \mathbf{+\ 34.28 \pm\ .90 \text{ to } \pm 1.28} \end{aligned}\right\} \mathbf{1875.0}$$

The signification of the two sets of probable errors attached to the respective quantities may be indicated as follows: We substitute the values of the unknowns in the conditional equations for each area, obtaining calculated values of the absolute terms. Table I contains the respective observed values, O, of $\mu \cos \delta$ and μ' for each area in that table. From these we obtain C − O as printed in Table I. Treating these as ordinary residuals, and remembering that the weight of the half-sectors from 101_1 to 108_2 is 0.5, we obtain as the probable error of weight unity in right-ascension, ±″.48; and in declination, likewise ±″.48. That is to say, the stellar parallactic motion in each area has been nominally determined with a probable error of ±″.48 both in $\Delta\alpha$ and $\Delta\delta$. The comparative smallness of this quantity implies that the peculiar motions of the stars must have been eliminated in a very satisfactory degree. Through this nominal probable error of the unit of weight, and with the weights of the unknowns resulting from the solutions of the normal equations, we are able to determine nominal probable errors of Δk, Δn, etc. These are the probable errors first given. For convenience it may be stated now that the probable errors following the first set depend upon the solution in seven zones, given later. These latter probable errors grow out of the discrepancies in the seven successive values of each of the unknowns, X, Y, and Z, found from the solutions in seven zones later on. They show the effect of regional anomalies more emphatically than do the probable errors first given. It is sufficient here to say that the increased amount of the second set of those probable errors, may be due in part to the operation of systematic errors of observation, especially in the southern one-third of the sphere. It may also be due in great part to defects in our fundamental hypotheses. For one thing, it will appear later, as had been anticipated, that the mean parallaxes of stars contained within Trapeziums in close vicinity of the Galaxy are smaller than for those at greater Galactic latitude. Also, there is doubtless some unbalancing, residual, effect from local star-drift, such as was recognized and taken account of in case of the moving cluster in *Taurus* (*A.J.*, No. 604).

However, the near agreement of the probable error of the unit of weight, as determined from the residuals of $\mu \cos \delta$ in right-ascension and from μ' in declination testifies, so far as it goes, to remarkable uniformity in laws and symmetry in distribution governing observed systematic effects inherent in the stellar motions themselves. It is true that here and there in the sky we may have decided tendencies to local star-drift without being able to identify with certainty the separate members of a group to which such drift probably belongs. The existence of such local effects would serve to increase discrepancies in the values of the unknowns from zonal determinations; but might also tend to compensate in the General Solution. Thus the true probable error of the unit of weight might be assumed to lie between the values determined in the foregoing.

SOLUTION FOR STARS OF MAGNITUDE, $6^{\mathrm{M}}.0$, AND BRIGHTER.

A solution for the values of the unknowns was made after all stars of magnitudes fainter than $6^{\mathrm{M}}.0$ had been excluded The number of stars thus excluded from the General Solution was 1864. This left 3,549 stars of the sixth magnitude, or brighter,— mean $5^{\mathrm{M}}.2$. The mean value of μ_0 for these stars is $5''.66$. The solution led to the following normal equations:

$$\begin{array}{rrrrrl}
\Delta k & \Delta n & X & Y & Z & \\
+70.64 & -\ .05 & +\ .09 & -\ .15 & +\ .00 & = -\ 26''.30 \\
-\ .05 & +70.09 & +\ .09 & .00 & -\ .15 & - +\ 18.42 \\
+\ .09 & +\ .09 & +71.07 & +\ .19 & -\ .36 & = -\ 1.97 \\
-\ .15 & .00 & +\ .19 & +70.09 & +\ .05 & = -229.84 \\
.00 & -\ .15 & -\ .36 & +\ .05 & +70.64 & = +159.94
\end{array}$$

These result in the following values for the unknowns:

$$\mathit{Mean\ Magnitude} = 5^{\mathrm{M}}.2 \quad ; \quad \mu_0 = 5''.66.$$

$$\begin{array}{lll}
\Delta k = -''.38 & X = -\ ''.01 & M = \ 3''.99 \\
\Delta n = +.27 & Y = -3.28 & A = \ 269^{\circ}.87 \\
 & Z = +2.27 & D = +\ 34.65
\end{array}$$

The results for Δk, Δn, A, and D are practically the same as from the main solution, when no star was rejected for magnitude. M, the systematic parallax, is now $3''.99$, instead of $3''.85$, as it is in the general solution. The mean magnitude of the stars in the General Solution is $5^{\mathrm{M}}.7$, and the mean of the motions, $5''.38$. The increase of M was indicated both in Y and Z as will be seen by comparing the two solutions. Nothwithstanding its small amount this increase seems to be real, as we should expect. So far as this goes, it indicates but a feeble effect of magnitude as a criterion of distance. It is probable, however, that a principle of selection has been operating in this instance, in some degree, by which the 1,864 stars below magnitude, $6^{\mathrm{M}}.0$, contain a larger ratio of large proper-motions than would have been the case if all the stars between $6^{\mathrm{M}}.0$ and $7^{\mathrm{M}}.0$ had been available. Among such stars, $6^{\mathrm{M}}.0$ to $7^{\mathrm{M}}.0$ or fainter, any one of them for which a sensible proper-motion was detected early in the nineteenth century would have been more diligently observed than others, and would then have become more eligible to be included in my *Preliminary General Catalogue*. That Catalogue was designed to include not only all stars down to the sixth magnitude, but also many stars below that magnitude that had the observations for specially accurate determination of proper-motion. Among these there was a strong likelihood that stars having centennial motions greater than 10″, say, would have received greater attention from the observers.

But this dropping of 1,864 stars from the 5,413 contained in the General Solution shows by coincidence of the positions of the solar apex in the two solutions, as well as by the close agreement of Δk and Δn, that the conditions of distribution of the peculiar motions and their general character has remained remarkably similar. It also indicates that the law of distribution of the motions peculiar to the stars themselves, must be operating very uniformly all over the sky upon different classes of stars. We shall also show that this point seems to be fairly well illustrated when we treat the material of observations in zones. The character of the proper-motions in widely divergent volumes of space seems to be remarkably similar.

SOLAR APEX FROM LARGE MOTIONS.

This is further shown by the treatment of stars having centennial motions generally included between 17″ and 80″. There were 559 of these, selected from the *P.G.C.*, on the same principles that were adopted in the General Solution heretofore discussed. The number of these is too few to form the basis of any very critical discussion. The peculiar motions cannot be very well eliminated from the small groups practicable for that purpose. Seventy-one such groups were formed. The minimum number of stars in any one group was five (occurring once), and the maximum number was 14 (also occurring once). The mean number was 8. Table V gives the particulars for these groups to correspond with those that were given in Table I (*A.J.*, 612). The mean of all the magnitudes was $5^{\mathrm{M}}.3$; and $\mu_0 = 31''.9$. Substituting for Δk, $-''.37$ as determined in the General Solution, and for Δn, $+''.34$, we have the following normal equations for determining X, Y, and Z:

SOLUTION FOR 559 STARS HAVING LARGE MOTIONS.

$$\begin{array}{rrrl}
+43.91\,X - & .14\,Y + & .13\,Z & = +\ 31''.7 \\
-\ .14 & +48.53 & +\ 1.54 & = -843.6 \\
+\ .13 & +\ 1.54 & +45.70 & = +531.8
\end{array}$$

Solving these equations we have the following values for the respective unknowns:

$$\begin{array}{lll}
X = +\ ''.63 & M = \ 21''.58 & \mu_0 = 31''.9 \\
Y = -17.77 & A = \ 272^{\circ}.03 & \dfrac{\mu_0}{M} = \ 1.48 \\
Z = +12.24 & D = +\ 34.53 &
\end{array}$$

The accordance of A, D and of $\dfrac{\mu_0}{M}$, seems to be good — accidentally better, even, than that demanded by the respective probable errors. The reader should also notice that, in order to correspond with our fundamental hypotheses, there should have been included in this part of the computation a certain small number of stars having proper motions less than 20″ which have already been included in the General Solution. It is naturally impossible to identify, and pick out from the others, the stars having proper-motions less than 20″ which really belong to this nearer volume of space. But the two solutions, one or the other of them, contain all the stars of the *P.G.C.* having proper-motions less than 80″. In combining the results of the two computations there will be some compensation.

The result shows that the principle of selection of stars to be included in the General Solution was effective and substantially correct. If we should attribute to this result for A and D, from 559 large motions a weight of one-eighth as compared with unity for A and D obtained in the General Solution, we should have from the combination of the two:

$$A = 270^\circ.69 \quad ; \quad D = +34^\circ.31$$

results which differ immaterially from those of the General Solution.

M represents the centennial parallax due to the solar motion at the approximate distance corresponding to the mean of the parallaxes of stars that appear in the solution. For example, in the General Solution, based upon 5,413 stars the centennial parallax, M, is 3″.85. For the discussion, based upon motions 17″ to 80″, of 559 stars we have, $M = 21''.58$. If we call the approximate mean distance of the first, unity (*i.e.*, $\rho = 1.0$) then for the approximate mean distance of the 559 stars we shall have, $\rho = 0.18$. It is, therefore, quite evident that in the latter case we are dealing with a volume of space that is quite distinct from any volume of similar extent contained in the first solution. Yet we see that the position of the solar apex applies equally to each, and the fundamental ratios, $\frac{\mu_0}{M}$, are consistent, when we make due allowance for the natural increase of this ratio with increase of μ_0 and for probable error in determination. Here again we must suppose that our fundamental hypotheses apply generally for all the stars of the *P.G.C.*, however distributed in distance, when stars down to $6^{M}.5$ alone are concerned.

In particular it seems to me that the hypothesis of random distribution of the motions peculiar to the stars themselves (or, at least, of symmetrical distribution) is greatly strengthened, though by no means proved.

Analysis of Solutions.

The probable errors for each of the unknowns in the General Solution are rather small for this class of computations. It is very important to get further light upon the reliability of these determinations, especially on those of Δk and Δn. Ordinarily, in an investigation like this, one has supposed $\Delta k = \Delta' m = \Delta n \cot \epsilon$, where ϵ is the obliquity of the ecliptic. Under this interpretation of results we should have these two values of $\Delta' m$, in the present case:

From right-ascensions direct, $-''.37 \pm ''.08$
Through $m = +''.34 \cot \epsilon$, $+ .78 \pm .18$

Here there is a discordance of 1″.15, if Δk is supposed to be due alone to the correction required for Newcomb's precession. Yet the theoretical probable error (on the higher estimate) of the difference is only ±″.20, nearly one-sixth of the discrepancy. This makes it practically certain than an important part of Δk is due to something other than error of adopted precession.

The more light we throw upon this point the better established it will appear to be. Thus, we have in Table II first, the normal equations formed from the right-ascensions alone, and next, those from declination alone. These were solved separately, and the results for the unknowns appear in Table IV. We have:

From right-ascensions, $\Delta n = +''.38 \pm ''.17$
From declinations , $\Delta n = + .33 \pm .10$

The probable error of the difference is ±″.19, and of the mean by weights, ±″.08. There is here excellent accordance between the two values of Δn, as well as between the two values of X and Y. Yet these two sets of results are derived from observations wholly independent of each other. The value of Δn from declinations might be very much influenced by adopted systematic errors of the form $\Delta\delta_a$; $\Delta\delta_a = a \sin \alpha + b \cos \alpha$. Δn, derived from the right-ascension, would evidently be free from systematic errors in declination. On the other hand it would encounter systematic errors in right-ascension of the forms:

$$\Delta\alpha_a = a \sin \alpha + b \cos \alpha \quad \text{and}$$
$$\Delta'\alpha_a = (a' \sin \alpha + b' \cos \alpha) \tan \zeta$$

and others similar in form to the latter. These are very real in some instances and may be ascribed to determinations of collimation, or polar-point, that are affected with systematic errors varying with the season. Many such were sought out and determined in course of the work preparatory to computation of the final motions incorporated in the *P.G.C.* (See *Appendix III of the Preliminary General Catalogue*). Now, the very fact that Δn, X and Y in the lines marked "R.A." and "Decl." in Table IV agree well within their predicted probable difference, ±″.20, suggests that the periodic systematic corrections that would affect the determination of those unknowns.

independently of each other in the two coordinates, have been determined and applied with a good degree of approximation.

ANALYSIS IN ZONES.

But before concluding this part of the subject we may test the results of the General Solution in another way. I have broken up the material contained in Table I, into four zones, each composed of two sub-zones, one north and the other south of the equator, in the manner described in the following:

TABLE III. NORMAL EQUATIONS BY ZONES.

	Δk	Δn	X	Y	Z	″
I	+17.82	+ .07	− .02	− .04	.00	= −10.99
	+ .07	+ 8.87	− .19	.00	− .04	= + 1.28
	− .02	− .19	+ 8.96	+ .06	+ .01	= − .16
	− .04	.00	+ .06	+ 8.87	− .07	= −26.57
	.00	− .04	+ .01	− .07	+17.82	= +36.63
II	+31.42	+ .01	+ .08	− .06	.00	= − 5.49
	+ .01	+19.83	.00	.00	− .06	= + 5.35
	+ .08	.00	+20.01	+ .12	− .09	= + .32
	− .06	.00	+ .12	+19.83	− .01	= −69.41
	.00	− .06	− .09	− .01	+31.42	= +66.05
III	+16.35	− .01	− .02	− .07	.00	= − 8.85
	− .01	+19.15	+ .13	.00	− .07	= + 7.04
	− .02	+ .13	+19.58	+ .13	− .11	= + 3.58
	− .07	.00	+ .13	+19.15	+ .01	= −62.16
	.00	− .07	− .11	+ .01	+16.35	= +41.94
IV	+ 5.06	− .11	+ .07	+ .06	.00	= − .73
	− .11	+22.30	.00	.00	+ .06	= + 9.85
	+ .07	.00	+22.26	.00	− .12	= − 3.36
	+ .06	.00	.00	+22.30	+ .11	= −64.64
	.00	+ .06	− .12	+ .11	+ 5.06	= + 8.19

I. First 18 Trapeziums of Table I containing stars between +10° and −10° of declination.

II. Trapeziums, 19 to 54, centers near + 20°, or −20°, so that the two zones, +10° to +30°, and −10° to −30°, are symmetrical with the equator.

III. Trapeziums, 55 to 82, containing the two zones, +30° to +50°, and −30° to −50°, likewise symmetrical with the equator.

IV. Finally, the two polar caps of radius 40° each, one at the north and the other at the south pole, comprised in the Trapeziums and half sectors, 83 to 108_2.

In this way we may hope to have complete elimination between Δk and Δn and the remaining unknowns.

The normal equations arising from the material arranged under the foregoing classification are found in Table III. The normal equations in each set represent combinations of conditional equations both in right-ascension and declination, half from the northern and half from the southern hemisphere, as already described.

The results of the solution of these four sets of equations are exhibited in the first compartment of Table IV. To each quantity in Table IV is attached its approximate weight, the unit being that of 10 areas (or Trapeziums), so that weight one corresponds to a probable error of ±″.15 when derived from the residuals, "C−O," in Table I, or to ±″.22 when derived from the agreement of seven separate values of X, Y, and Z, as derived from a later discussion.

TABLE IV. VALUES OF Δk, Δn, X, Y, AND Z, FROM VARIOUS SOLUTIONS.

	Δk	Wt.	Δn	Wt.	X	Wt.	Y	Wt.	Z	Wt.
	″		″		″		″		″	
I	−.62	2	+.16	1	.00	1	−2.98	1	+2.05	2
II	−.20	3	+.28	2	+.05	2	−3.50	2	+2.10	3
III	−.55	1½	+.38	2	+.22	2	−3.25	2	+2.57	1½
IV	−.10	½	+.44	2	−.14	2	−2.91	2	+1.67	½
V	−.22	1	+.23	1	−.02	1½	−2.71	1	+1.78	1
VI	−.24	1½	+.55	1	−.05	2	−3.32	1	+1.90	1½
VII	−.34	2	+.14	2	−.01	2	−3.44	2	+2.35	2
VIII	−.52	3	+.42	3	+.03	1½	−3.11	3	+2.30	2½
R.A.	−.37	7	+.38	2	+.00	5	−3.22	5	..	..
Decl.	..	..	+.33	5	+.03	2	−3.03	2	+2.16	7
Comb. all	**−.37**	**7**	**+.34**	**7**	**+.03**	**7**	**−3.18**	**7**	**+2.17**	**7**

Unit of weight is 10 areas, corresponding to a probable error of from ±″.15 to ±″.22.

In order to embrace the entire treatment of this branch of the subject, I have also introduced into Table IV the values of the unknowns obtained from zones V, VI, VII, and VIII, arranged in order of Galactic latitude, as explained farther on. The total observational material of Table I is used in each of these sets of zones; but in each set, each zone is independent of the other three. In both sets the agreement of the values of the respective unknowns seems to be satisfactory. Not only is there not a single positive value of Δk, but there are no abnormal values of any kind. This seems to provide another striking testimonial to the accuracy of the systematic corrections employed in deducing the proper-motions from the star-catalogues of observation. Those for the southern one-third of the sky are naturally much less reliable than the northern, since they are based on far less material of observation.

But further than this, one is also justified in attributing the good agreement of the respective unknowns, derived from the four regional areas, in part to the probability that the distribution of peculiar motions is so symmetrical in each region that they are almost completely eliminated in each of the solutions. The presence in any sub-zone

TABLE V. MATERIAL IN GROUPS FOR CONDITIONAL EQUATIONS. PROPER MOTIONS, 20″ to 80″.

No.	No. Stars	Mean Mag.	1875 R.A.	1875 Decl.	Mean μ_0	$\mu \cos \delta$	μ'
		M	h m	°	″	″	″
1	6	5.3	0 20	+23.0	33.1	+ 0.4	−19.8
2	6	5.2	0 28	−12.8	30.6	+11.1	−10.0
3	14	5.8	1 21	− 2.7	29.0	+ 6.7	−11.1
4	6	4.5	1 24	+35.5	29.7	+ 6.4	− 9.3
5	8	5.5	2 31	+15.7	27.5	+13.2	−12.2
6	10	5.6	2 26	− 5.0	30.1	+10.0	−12.0
7	8	5.4	2 40	−27.7	36.7	+14.6	+ 8.1
8	6	5.4	3 25	− 1.1	29.6	+10.5	−15.6
9	7	5.2	4 17	−22.9	27.6	− 2.1	−10.8
10	7	4.9	4 44	+15.5	35.8	+24.2	−15.5
11	7	5.1	6 4	−29.2	43.2	+ 0.6	−27.5
12	7	5.0	6 5	+11.2	24.9	− 8.8	− 9.4
13	9	4.6	7 24	+28.1	31.4	−13.2	−13.2
14	6	5.8	7 29	−12.6	25.6	− 8.3	− 7.3
15	6	5.3	8 23	+ 8.2	21.4	−14.9	− 9.0
16	5	5.4	9 15	−21.7	34.8	− 8.3	+15.2
17	9	5.5	9 41	+23.5	36.1	−20.8	−12.7
18	7	4.9	9 50	− 1.7	23.2	−15.2	− 3.7
19	9	4.9	11 11	−22.4	28.9	−16.6	+ 0.6
20	11	5.1	11 33	+ 7.5	33.3	−25.3	− 6.4
21	7	5.7	11 24	+28.0	39.1	−23.0	−21.3
22	8	5.5	12 42	−14.8	33.2	− 9.0	−16.7
23	11	5.2	13 8	+ 3.5	38.2	−21.3	− 8.5
24	10	5.1	13 32	−32.5	42.8	−32.2	−12.3
25	6	4.7	13 47	+15.9	40.2	−27.6	−16.3
26	7	5.3	14 32	+32.9	23.1	− 4.2	0.0
27	8	5.1	14 55	− 7.0	40.8	+ 1.4	−23.2
28	9	5.5	14 58	−34.2	25.7	−20.7	−10.7
29	8	5.2	16 2	+35.8	33.8	− 7.9	− 6.4
30	8	5.6	16 16	+ 6.6	40.6	− 3.2	−28.3
31	6	4.4	17 36	−26.4	31.9	− 9.1	−21.9
32	6	4.4	17 52	+ 1.3	23.9	− 0.7	−17.6
33	9	4.8	18 42	+28.7	29.5	− 1.0	−17.0
34	9	5.8	19 41	−19.1	36.2	+ 3.7	−25.2
35	10	4.4	20 8	+ 9.0	35.3	+10.7	−13.7
36	6	4.6	20 37	+38.3	37.8	+10.3	+ 0.5
37	6	5.7	21 38	+25.1	32.7	+11.4	−15.5
38	7	5.8	22 12	− 0.1	30.8	+13.9	−13.2
39	12	5.1	22 14	−20.6	29.4	+14.0	−13.2
40	9	5.8	22 52	+16.7	36.1	+26.1	− 3.3
41	11	5.6	23 17	− 4.7	37.9	+28.6	− 8.8
42	6	4.6	0 48	+59.0	36.4	+30.7	− 4.4
43	8	5.3	3 2	+43.1	26.0	+16.3	−14.7
44	7	6.6	5 22	+74.7	40.9	+11.3	−20.1
45	7	5.2	6 4	+54.2	32.9	− 0.6	−26.6
46	8	5.4	8 58	+40.2	49.0	−33.8	−30.0
47	8	5.7	10 21	+45.3	28.9	− 5.8	−10.0
48	7	6.4	11 52	+69.0	29.2	−17.2	+ 4.2
49	8	6.1	12 6	+46.5	34.6	−24.1	− 0.3
50	7	5.6	14 29	+50.2	29.6	−18.4	− 3.2
51	8	6.2	15 21	+77.8	29.5	+ 1.3	+ 3.5
52	6	5.8	17 22	+62.8	36.6	+ 2.8	− 6.6
53	5	4.8	18 12	+72.8	33.1	+ 9.1	+ 0.6
54	8	5.9	18 58	+50.7	29.5	− 3.6	+19.1
55	9	5.6	21 14	+57.6	29.3	+17.1	+ 8.2
56	6	5.8	23 0	+76.4	25.2	+14.6	+ 2.7
57	10	5.8	23 22	+44.8	26.0	+ 9.1	+ 4.9
58	10	5.6	0 17	−44.4	35.4	+24.6	−10.5
59	10	5.0	1 45	−52.1	34.4	+24.2	+ 8.0
60	6	5.8	4 16	−42.0	21.3	+ 5.4	+ 0.6
61	9	5.0	4 34	−59.4	31.2	+12.1	+22.0
62	10	5.3	7 4	−43.6	30.9	− 4.3	+13.8
63	12	4.7	7 43	−68.8	27.2	− 2.5	+ 9.6
64	6	5.6	9 58	−39.0	30.3	−25.2	+ 2.3
65	6	5.0	12 11	−45.6	23.0	− 3.4	− 4.8
66	10	4.2	12 42	−63.6	25.1	−11.3	−10.4
67	6	4.9	17 2	−70.3	31.1	− 7.4	−14.6
68	7	4.1	17 33	−44.4	24.3	− 0.3	−22.2
69	7	5.8	20 17	−43.0	35.4	− 1.7	−27.0
70	8	5.5	22 2	−74.0	29.0	+14.3	−13.9
71	7	5.4	22 19	−49.6	35.9	+ 6.5	−21.1

of relatively large unbalanced group-movements of stars belonging to an apex decidedly non-conformable with that of the solar apex here found would seriously affect the values of the unknowns and would attract the attention of the computer. For instance, Trapezium 22, as it stands in Table I contains 57 stars, including four stars to represent the *Taurus* group (*A.J.*, 604), and $\mu \cos \delta$ for that group is +1″.58 with "C−O" equal to −″.72. But if there had been also included 31 stars which have actually been rejected, as belonging to the *Taurus* group, we should have had: $\mu \cos \delta = +4''.46$, and $C-O = -3''.60$. This would have produced intolerable discordance for Trapezium 22. Anomalies in other areas (in 87, for instance) are known to be the result, in part, of group motions.

How to deal with such groups is a matter open to some doubt. It is clear that double and multiple star-systems should be treated as units. They have been so dealt with, even when the components are separated by large fractions of a degree. There seem to be no sharp dividing lines between multiple star-systems, in the ordinary sense, and these groups extending over large areas. It is difficult, or impossible, to make an infallible selection as to the stars that actually belong to such systems. There is always the chance that a small percentage of stars may seem to belong to such a system, when such an appearance may be brought about by pure accident; and when the sky-area of such a group is large, the chance of such spurious members of the group is greater. I should hesitate to take these group-motions into account, and to reject a certain large proportion of them, unless the evidence in favor of that course were very convincing. No doubt some improvement would have been brought about if the *Ursa Major* group had been investigated and only one star of this group had been allowed to remain in each Trapezium as its representative. Furthermore, we have instances among stars having small motions (say 4″±) where evidence of the existence of a common motion for a comparatively large number of stars is strongly suggested. Yet it is practically impossible to demonstrate the existence of such common motion, because the errors of observation become relatively so important as to render the solution of the problem indecisive. We are unable to make a definite selection of stars that really belong to the group. Time will cure these difficulties.

The anomalies which may exist on account of the disturbing effect of group-motions, not taken into account, seem to be the most important that we have to fear; and even these do not appear important enough to cause any serious distrust of deduced values of Δk and Δn.

Precession and Motion of the Equinox.

The fair agreement of Δk, as derived from zones in two arrangements (Table IV), might be held to indicate a small rotation of the stellar sphere about a celestial axis nearly parallel with the terrestrial polar axis. There is no *a priori* probability in favor of this. Rotation about an axis approximately perpendicular to the plane of the Galaxy has been suggested as among the possibilities. The *a priori* probabilities would seem to be more in favor of a possibility of rotation of this latter character. This possibility rests on speculation only. It might be a rotation as of a rigid mass, or it might vary with the distance of stars from some axis or center to be determined. In the latter case it would be necessary to fix the relation to the sun of this origin of rotation. This would increase the difficulty of the solution. I consider it highly improbable that any such rotation exists that amounts to more than a small fraction of a second per century.

On the other hand, a veritable cause for a contradiction of sign between Δk and Δn in our present discussion may exist in the uncertainty about the motion of the equinox, Δe, upon which our computations of right-ascension and of μ are based. This equinox is known as N_1, published about 40 years ago in Newcomb's *Right-Ascensions of the Equatorial Fundamental Stars, Appendix III, Washington Observations* for 1870. The direct determination of Δe, rests upon observations of the Sun to determine the position of the equinox at successive epochs. Such positions are subject to large constant errors, of which those appertaining to transits of the Sun are not always the most important part. The results of various series of determinations exhibit great discordances. When Newcomb undertook to revise N_1, these discordances led him to bring to his aid deductions of the motion of the equinox from observations of the planets, especially of *Mercury*. The latter led to positive corrections of the result derived from observations of the Sun. He decided upon $+''.30$ (*Astronomical Constants*, p. 88) as the most probable correction of the motion of his former equinox, N_1, as represented in his right-ascensions of the Equatorial Fundamental Stars. This correction did not seem to meet the approval of astronomers generally. Recurring to the subject later (*The Precessional Constant*, p. 70), Newcomb discussed the Greenwich Observations of the Sun, 1835 to 1895, and found, $\Delta e = +''.5$. He also restates his confidence in the value derived from the observations of *Mercury*: $\Delta e = +1''.0$. Summing up he says: "Altogether I conceive that the existing material justifies us in anticipating for this correction (to N_1) a value: $\Delta e = +''.30$." There is much in Professor Newcomb's contention concerning the superior value for this purpose of a long series of observations of the Sun at the same observatory, with many observers, and few instrumental changes. Still later Newcomb recurred to this subject again (*Ast. Jour.* No. 498, Vol. XXI, p. 141). He there shows that the mean of later Greenwich and Washington observations of the Sun give the following corrections to the right-ascensions, N_1:

Washington Observations,	1894–1899	$+\overset{s}{0}.053$
Greenwich Observations,	1893–1899	$+0.005$

Newcomb's conclusion is that the right-ascensions of the stars in his system, N_1, require a correction for 1896 "of which the most probable value may be set at $+^{s}.02$ or $+^{s}.03$." This is in harmony with his previous conclusions. The foregoing considerations, brought forward in Newcomb's latest commentaries on this subject seem to render quite plausible the admissibility of a material and positive equinox-correction to proper-motions in right-ascension employed in this discussion, and consequently to the value of Δk. The great uncertainty which attaches to the determination of Δe from observations of the Sun is apparent.

Accordingly, in the introduction of my *Preliminary General Catalogue*, p. XXIX, I have attempted in a rough way to apportion the corrections for Δe and for precession, so as to reconcile Δk and Δn, so far as it seems prudent to do so. For convenience I submit the substance of this adjustment. We put:

$\Delta k = \Delta' m - \Delta e_0 - \Delta\lambda = -''.37$, as at the outset (*A.J.*, 612). The signs are so arranged as to make the unknowns, with positive signs, indicate corrections to the quantities they respectively represent. For an independent determination of Δe we have from Newcomb's later researches, as indicated in the foregoing, $\Delta e = +''.30$ We have: $\Delta' m = \Delta n \cot \epsilon = +''.34 \cot \epsilon = +''.78$, as derived from the present discussion. ϵ represents the obliquity of the ecliptic for 1875. $\Delta\lambda$ represents the planetary precession for which I put:

$$\Delta\lambda = {}''.00 \quad \text{(Newcomb)}$$

We then form the following equations of condition, with weights given them by estimation, founded on careful consideration of the respective uncertainties. The weight assigned to $\Delta' m$ is equivalent to 10.6 for Δn.

Adjustment Equations.

Weights		Obs.	Comp.
10	$\Delta' m - \Delta\lambda - \Delta e =$	$-\,''.37$	$-\,''.32$
1	$\Delta e =$	$+\ .30$	$+\ .79$
8	$\Delta\lambda =$	$.00$	$+\ .06$
2	$\Delta' m =$	$+\ .78$	$+\ .53$

The adjustment by least squares results in the following:

$$\begin{array}{llr} \Delta' m = +''.53 & \Delta m = \quad +''.53 - ''.06 = & +''.47 \\ & \Delta n = & +\ .23 \\ \Delta\lambda = +\ .06 & \Delta k = & -\ .32 \\ & \text{Correction to} & \\ \Delta e = +\ .79 & \text{Luni-solar Precession,} & +\ .58 \end{array}$$

All corrections are for the epoch, 1875.

From these I conclude that the adjusted corrections to the centennial proper-motions of the *P.G.C.* should be:

$$\text{for } \mu \quad : \quad +0\overset{s}{.}021 - 0\overset{s}{.}015 \sin\alpha \tan\delta$$

$$\text{for } \mu' \quad : \quad -\,0.''23 \cos\alpha$$

Applying these corrections to the proper-motions of *P.G.C.* we derive the proper-motions which I have adopted in some subsequent discussions, as best representing the true value of those motions made as free as possible from errors of equinox and precession.

The derivation of the motion of the equinox from the observed motions of the stars — mainly through determination of the Luni-solar precession, through its component, n — is open to something like an analogous objection that applies to the determination of the solar parallax by means of the constant of aberration and the velocity of light.

In view of the unknown systematic errors to which observations of the Sun are liable, especially when applied to determinations of the position of the equinox, it seems to me that we are justified in experiencing a greater fear of these, than of the unknown systematic errors that may exist in determining the motion of the equinox from the systematic motions of the stars.

Velocity V, Corresponding to M.

It is evident that, if we have M, the solar parallactic effect for a group of stars, and if, at the same time, we have the measured annual parallaxes, π, of those stars, it will be possible to determine the ratio of M to π, and by this means we will be able to determine the velocity, V, of the Sun in space. Evidently the ratio of M to π will be easier to determine from the large proper-motions. In the preceding pages we have for 559 stars (of mean motion 31''.9, mean magnitude $5^{M}.3$) $M = 21''.58$. We need now to know the average annual parallax, π, of these same stars in order to determine the ratio of M to π.

The annual parallaxes of something over 200 stars, having proper-motion of ''.17 or greater, have been fairly well determined. Of these, 91 are of the seventh magnitude, or brighter, and of proper-motion less than ''.80. Of the 559 stars:

428 stars have motions less than	''.40
100 stars have motions between	''.40 and ''.60
31 stars have motions between	.60 and .80

The parallaxes of only 27 stars, having motions less than ''.40 and above ''.16, have been well determined. The mean annual motion, μ_0, of the 91 stars is ''.486; and for this we have no determination of the corresponding M.

As we have seen, the mean of the solar parallactic motions of any fairly homogeneous group of stars is approximately proportional to the corresponding means of the proper-motions. Thus we have for the ratio of $M : \mu_0$ from the respective solutions:

	μ_0	$M : \mu_0$	Magn.
	''		M
From the General Solution	5.38	0.715	5.7
From 3549 stars of $6^{M}.0$ and brighter	5.66	0.705	5.2
From 559 large proper-motions	31.90	0.677	5.3

The ratio of M to μ_0 diminishes as μ_0 increases, and from what follows in the discussion of measured annual parallaxes, it will appear that this diminution is real. The drop of this ratio in the last group is apparently satisfactorily explained on the hypothesis that, among the larger proper-motions, there is proportionally a greater number of stars that have abnormally large rectilinear motions, peculiar to the stars themselves. We might extrapolate through the ratios for the second and third groups, which pertain to stars of nearly the same mean magnitude, and thus find a computed ratio, $M : \mu_0$, corresponding to $\mu_0 = 48''.6$. For this ratio we find $M : \mu_0 = 0.659$, and annual $M = ''.320$. The mean π for the 91 stars, having motions of ''.17 to ''.80, is ''.056. Thus we have $M = 5.71\ \pi$; and $V = 5.71R$, where R is the radius of the Earth's orbit. If the mean motion of the Earth in its orbit be taken equal to 29.76 *km* per second, then we have $V = 27.0$ *km*. But this extrapolation of the ratio of M to μ_0 must be regarded as extrahazardous and unsatisfactory; and, therefore, no great confidence can attach to the value of V so determined.

I next proceed in an attempt to formulate the ratio of π to μ_0 in order to obtain a value of that ratio when centennial μ_0 is equal to 31″.9. M. BIGOURDAN's list of measured values of π contained in *Bulletin Astronomique*, Tome XXVI, July to December, 1909, offers facilities for the prosecution of such an inquiry. In compiling a tabulation in groups of the observed values of π, I have taken the magnitudes and proper-motions from my own records. In deciding upon an adopted value of π for each star I have greatly preferred the results from heliometer-measures as well as those from recent photographic methods, where powerful telescopes have been employed; though some weight was occasionally assigned to π, obtained by other methods. The result for *Br.* 3512 (16 *Cygni*) was excluded. The measurement is by JOST, method of transits. We have $\mu = ''.22$; $\pi = ''.153$. The chances seem to indicate that this is probably an abnormal value or an unusually large error of observation. No annual proper-motions exceeding 6″ were employed. It appears that the ratio of π to μ_0 diminishes rapidly with fainter magnitudes. The first tabulation was, therefore, limited to stars of $7^M.0$, or brighter, in order that these should correspond as closely as practicable to the mean magnitude, $5^M.3$, of the 559 stars.

TABLE OF MEASURED VALUES OF π AND OF $\pi : \mu_0$.

No.	Wt.	Magn.	μ_0	π'	π	$\pi : \mu_0$ Obs.	$\pi : \mu_0$ Calc.
		M	″	″	″		
11	0	4.6	3.18	.152	.156	.049	.058
28	3	5.0	1.19	.130	.134	.113	.109
27	3	5.4	0.69	.064	.068	.098	.121
37	3	5.2	0.51	.059	.063	.124	.126
27	1	[5.3]	0.25	.037	.035	.140	.133

The actual mean magnitude for the last group was $3^M.6$, and I have employed KAPTEYN's "Table G" (*Publ. Ast. Lab., at Gröningen, No.* 8) to reduce π' to adopted π, at magnitude $5^M.3$. The reduction is $-''.006$. Then to all the published values of π' I have added $+''.004$ as a correction for the mean parallax of the comparison stars, which are in the mean very nearly of the eighth magnitude. KAPTEYN's researches would make this quantity about $+''.007$, which appears to me too large, especially, because the observers would naturally avoid comparison stars having comparatively large proper-motions. If we assume that the ratio, $\pi : \mu_0$, diminishes in proportion to $\frac{1}{\mu_0}$ we have:

$$\frac{\pi}{\mu_0} = +.131 - .0256\,(\mu_0 - .32) \quad (A)$$

From this formula the last column, "Calc," of the table, has been computed. The agreement with "Obs." seems to me quite satisfactory. No weight was assigned to the group in which annual μ_0 is 3″.18. The stars in this group fainter than $7^M.0$ indicate a much larger value of π. Including these we should have had for 18 stars $\mu_0 = 3''.16$; mean Magn. $= 6^M.1$; and $\pi = ''.183$. With the correction to mean magnitude $5^M.3$, after KAPTEYN, we would have: $\pi = ''.201$, and $\pi : \mu_0 = .064$. This would have been in excellent agreement with the computed value, .058.

My conclusion is that, for our group of 559 large proper-motions, formula (A) applies with a fair degree of approximation. This would give for annual μ_0 ″.319, $\pi : \mu_0$ equal to .131. We already have $M : \mu_0 = .677$. Consequently we have:

$$\frac{M}{\pi} = \frac{.677}{.131} = 5.17\,R\,. \qquad V = 24.5\ km.$$

This I shall call the adopted value of V by the method of thwart motions and measured annual parallaxes.

The following tabulation of measured π for stars fainter than $7^M.0$ was prepared in the same way as that for the brighter stars already given.

MEASURED PARALLAXES FOR STARS FAINTER THAN $7^M.0$

No.	Magn.	μ_0	π'	π	$\pi : \mu_0$
	M	″	″	″	
7	8.5	3.12	.223	.227	.071
18	8.2	1.16	.058	.062	.053
18	7.8	0.67	.018	.022	.033
34	8.0	0.53	.030	.034	.064
5	7.8	0.30	.010	.014	.047

Here there is evidence of greater anomalies than those which appear to be revealed in the tabulation for the brighter stars. The indicated dependence of π upon the argument, magnitude, is very pronounced. In fact, according to this tabulation, the relative distance of stars of this class, of mean magnitude $8^M.0$, as compared with the former group of stars of mean magnitude $5^M.3$, is roughly about two-thirds what it would be, if magnitude were an absolute criterion of distance. It is quite certain that this is not the case with motions of the class contained in the General Solution. Probably something is due to the greater difficulty of measuring parallaxes of faint stars with the heliometer, and to effect of casual errors when we are dealing with such a small number of stars in some of the groups. But it seems almost certain that there is a relatively unusual proportion of abnormally large peculiar motions in the third group (of 18 stars) having mean motion, 0″.67.

My conclusion is, that we need many more measures of annual parallax upon stars having proper-motion greater than 0″.20 before we can hope for any radical improvement upon the valuable researches of KAPTEYN upon this subject. This is especially desirable for stars having motions between 20″ and 40″.

The facility, accuracy, and economy of labor, with which annual parallax can now be measured when photographic methods are employed with the aid of comparatively powerful telescopes, stimulates hope that we shall be able to attack this problem much more successfully in the comparatively near future.

We may also compute V from measurements of motions of stars in the line of sight (radial velocities) and in two ways, when the ratio of M to μ_0 is available.

From the General Solution we have, $\mu_0 = 5''.38$ and $M = 3''.85$, and thus the ratio: $\frac{\mu_0}{M} = 1.40$. Recurring now to Mr. Raymond's Table II (*A.J.*, 609, p. 73) and employing this ratio 1.40 as the argument, we find for V, the velocity of the Sun's motion corresponding to M:

$$V = .66\ r_0$$

This r_0 represents the mean velocity of the motions peculiar to the stars themselves, otherwise denoted as v. The accuracy of the factor, .66, in the foregoing equation may hereafter be tested when we shall be in possession of the measured velocities in the line of sight of a sufficient number of stars, well distributed all over the sky in both hemispheres. Some indication may be had from Professor Campbell's paper in the *Astrophysical Journal*, Vol. XIII, p. 84. Basing his results on the measurement of the radial motions of 280 stars — none south of $-30°$ and very few south of $-15°$ — Campbell finds: $v = 34.1 km$. Deriving from his measurements of radial velocities the constants of the solar-apex he gets, directly: $V = 19.9 km$. At the same time he has: $A = 277°.5$, and $D = +20°.0$. With our ratio, $V = .66\ v$, we have:

$$V = .66\ v = 34.1\ km \times .66 = 22.5\ km$$
$$V = \text{(as directly measured)}\quad 19.9\ km$$

But we have already found from the method of combining μ_0 with measurement of annual parallaxes: $V = 24.5\ km$. This seems to agree well with the above value of V (22.5*km*) derived through the employment of the ratio : $V = .66 r_0$. At the same time Campbell finds (*Astroph. Jour.*, Vol. XIII, p. 85) that for 121 stars fainter than $4^M.0$ the mean stellar velocity, v, derived from his measured motions is 38.9*km*. This would give for V, 25.6*km*. The question whether the average velocities for the fainter stars are greater than for the brighter is one that requires the presentation of much more evidence than we now have before it can be accepted as a general law.

As the matter stands, we must regard the determination of V through the various methods to be as consistent with each other as could fairly have been expected. Owing to the unsymmetrical arrangement of the individual measures of radial velocities relatively to the apex and anti-apex of solar motion, the direct determination of V by the spectroscope ($V = 19.9\ km$) is open to objection.

At present, in view of all the evidence, I am of the opinion that the hypothesis of random motion of the stars receives strong support in these results. In this view of the case we might consider as a useful constant for the present,

$$V = 24\ km.$$

Further Tests of M, A and D.

In order to test the reliability of the values of the unknowns in our General Solution, I have thought it desirable to examine the observed results for more limited areas than heretofore. Accepting the values of Δk and Δn, $-''.37$ and $+''.34$ respectively, we can substitute these in limited zones not symmetrical with the equator, and thus avoid a degree of indetermination which exists between these and X, Y, and Z. I have divided the material of Table I into seven zones as follows:

I. The Trapeziums from 1 to 18 inclusive; limits $+10°$ to $-10°$ of declination.
II N. Stars between the parallels $+10°$ and $+30°$.
II S. Stars between the parallels $-10°$ to $-30°$.
III N. The zone, $+30°$ to $+50°$.
III S. The zone, $-30°$ to $-50°$.
IV N. The north polar cap, $+50°$ to the north pole.
IV S. The south polar cap, $-50°$ to the south pole.

The results of the solutions are given in Table VI.

The weight of a determination resulting from an average of about 770 stars, only, will necessarily be somewhat smaller, even, than the proportion of the material employed. Also the weights of X, Y, and Z are unevenly distributed, that of Z in IV N and IV S being only 2.5 for example. This is only one twenty-eighth of the weight of Z in the adopted solution, corresponding to a probable error of about $\pm''.44$; while the probable error of Z in the general solution is from $\pm''.06$ to $\pm''.08$. The low value of D in the solution of II S (see Table VI), and the low value of M in the solution of IV N, furnish instances that can be strongly suspected of arising from serious anomalies in the distribution of proper-motions within the areas respectively concerned. Yet it would be difficult to trace these anomalies to their sources and to identify the stars whose motions have caused the anomalies. Apparently Trapeziums 44 and 45 contain groups of stars that are responsible for the large residuals C − O, given for those areas in Table I. The *Ursa Major* group is within the limits of the area IV N, and the Trapezium 87 appears to be much influenced by the retention of several stars of that group. It is evident, too, that the values of μ_1 (mean of the proper-motions in a single area) are unduly dependent upon the larger motions that happen to be contained within them. This can scarcely be avoided in the present state of our resources; though it might be possible to classify the proper-motions less than 20″, into two groups, much as the proper-motions less than 20″ have been separated from those between 20″ and 80″. Remarkable instances of the paucity of motions above 5″ in some of the Trapeziums are furnished later on.

It is fair to suppose that the southern zones have been affected in a larger degree than the northern by systematic errors of observation that have not been well eliminated. This is due to the small number of extensive star-catalogues of fundamental character that are available in the southern hemisphere, and to the shorter period over which they extend. The value of D in II s seems to be affected by a general conspiracy of small anomalies, working together in a cumulative effect, of which imperfectly eliminated systematic errors of observation may be one element.

There seems to be nothing in the progression of the values of A, D, and M in Table VI indicating any decided systematic variations of these quantities with distance from the equator. The significance of this fact is important mainly in its confirmation of the general accuracy of the systematic corrections of star-catalogues of observation employed in computing the proper-motions.

Computing the probable errors of X, Y, and Z, corresponding to the unit of weight 10, the mean weight of each determination, we find it to be ±″.22. But for the p.e. of the mean of 10 Trapeziums, assuming the p.e. of a single one, as ascertained in the General Solution, to be ±″.48 we find ±″.15. From this we infer that in each combination of 10 Trapeziums there is a probable error of about ±″.16, due to the action of anomalous sources of discrepancy, suspected or unknown, that is virtually not included in the probable error of ±″.48 computed for a single Trapezium; or rather, we may suppose the probable error of a single Trapezium equal to $\sqrt{(.45)^2+(.16)^2}$. The foregoing computation is not very rigorous, and the number of residuals employed is too few (21) to have any very exact meaning; but it does probably suffice to indicate, in a rough way, the magnitude of anomalies which may be expected in regional combinations. Group anomalies, for example, may exist in a limited region, which may be balanced in essential sign by those in other limited areas, when the entire sphere is taken into account. Other anomalies may be developed when we come to arrange the solutions in order of Galactic latitude.

Table VI. Solutions by Zones.

Zone	Limits	X	Wt.	ε	Y	Wt.	ε	Z	Wt.	ε	M	ε	A	ε	D	ε
	° °	″		″	″		″	″		″	″	″	°	°	°	°
IVn	+50 to +90	+.03	11	±.21	−2.62	11	±.21	+1.26	2.5	±.44	2.91	±.27	270.7	±4.7	+25.7	±8.0
IIIn	+30 to +50	+.40	10	.22	−3.31	10	.22	+2.61	8	.24	4.23	.23	276.9	4.0	+38.1	3.3
IIn	+10 to +30	+.03	10	.22	−3.33	10	.22	+2.48	16	.18	4.15	.21	270.5	4.0	+36.7	2.7
I	+10 to −10	00	9	.23	−2.98	9	.23	+2.05	18	.17	3.62	.21	270.0	4.4	+34.5	3.0
IIs	−10 to −30	+.04	10	.22	−3.68	10	.22	+1.72	16	.18	4.06	.21	270.6	3.8	+25.0	2.6
IIIs	−30 to −50	+.03	10	.22	−3.19	10	.22	+2.53	8	.24	4.07	.23	270.5	4.1	+38.4	3.3
IVs	−50 to −90	−.33	11	±.21	−3.19	11	±.21	+2.09	2.5	±.44	3.83	±.30	264.1	±3.9	+33.1	±5.9

SOLUTIONS IN ZONES OF GALACTIC LATITUDE.

When we provide for solutions in zones of Galactic latitude, some peculiarities are developed that indicate that there are systematic relations of distance, or arrangements of the proper-motions, that seem to have dependence upon Galactic latitude as an argument. I have taken the areas contained in Table I, and have arranged them roughly in Galactic zones. The limits of these zones are zig-zag lines instead of strict parallels. The respective contents of these zones are distinct, one from another, and may be described as follows:

V. All areas whose centers are of Galactic latitude ±7°, or less; 1,263 stars.

VI. All areas whose centers have Galactic latitudes between +7° and +19°, or −7° and −19°; 1,168 stars.

VII. All areas having centers between latitudes +19° and +42°, or between −19° and −42°; 1.518 stars.

VIII. All areas whose centers are north of +42°, or south of −42°; 1,464 stars.

Normal equations were formed in the manner described under the previous General Solution and solved for Δk, Δn, X, Y, and Z. Table VII contains the results of the solution of these equations. There is here good accordance in the values of the unknowns, Δk, Δn, A, and D. There seems to be no really marked progression of Δk and Δn with Galactic latitude. In fact there is good accordance, when the weights are considered, ±″.16 being a rough predicted mean value of the probable error for each. The same accordance appears in the position of the solar apex arising from the several partial solutions. X is always small, and the progression in values of Y is matched by that in Z. With increase of Galactic latitude values of $\frac{\mu_0}{M}$ increase in a very striking way. This increase mainly depends upon the increase of μ_0 and does not appear to be wholly the result of accident. A very small part of this may be due to the relation of the several areas to the apex of solar motion. In the little table presently to be given the observed values of μ_0 are repeated from Table VII, immediately after the designation of the respective areas. This can be verified from Table I. Theoretically μ_0 should not be constant for these areas. It should vary with mean angular distance from the solar apex, in the manner deducible from Table I of Mr. Raymond's paper in the *Astronomical Journal*, No. 609. We have already found μ_0 from the entire sphere to be 5″.38. This gives us $\frac{\mu_0}{M} = 1.40$; and $M = .66\, r_0$, r_0 being the mean peculiar motion of a star. Then entering Mr. Raymond's, Table I, "For a limited area." (*A.J.*, No. 609, p. 73) and with $m = M \sin \Delta$, in which Δ is the north-polar distance from the apex of solar motion, we have the calculated value of μ, for each partial area or Trapezium. Integrating these for each regional area, V, VI, VII and VIII, we have the regional values of μ_0 (under C in the table presently to be given) that would be consistent with $\mu_0 = 5''.38$ for the entire sphere and with $M = .66\, r_0$. In these values of C we have a slight computed variation with Galactic latitude. But after allowing for this, we still have nearly the whole of the observed variation, as shown under "$C - O$."

Values of μ_0

Region	Obs.	C	C−O
	″	″	″
V	3.81	5.24	+1.43
VI	4.77	5.31	+ .54
VII	5.68	5.38	− .30
VIII	6.27	5.49	− .78

Table VII. Solutions by Zones According to Galactic Latitude, b.

Zone	b	No. Stars	Mag.	μ_0	Δk	Δn	X	Y	Z	A	D	M	$\frac{\mu_0}{M}$
	° °		M	″	″	″	″	″	″	° ′	° ′	″	
V	− 7 to + 7	1263	5.5	3.81	−.22	+.23	−.02	−2.71	+1.78	269 40	33 17	3.24	1.18
VI	+ 7 to +19 − 7 to −19	1168	5.6	4.77	−.24	+.55	−.05	−3.32	+1.90	270 55	29 52	3.82	1.25
VII	+19 to +42 −19 to −42	1518	5.8	5.68	−.34	+.14	−.01	−3.44	+2.35	269 51	34 18	4.17	1.36
VIII	> +42° > −42°	1464	5.9	6.27	−.52	+.42	+.03	−3.11	+2.30	270 32	36 27	3.87	1.62

This progression in observed values of μ_0, standing by itself, might be held to indicate a corresponding variation in the mean parallaxes of the stars constituting the successive Galactic zones. The deduced mean parallaxes, M, do progress as shown in Table VII, but not in so great a ratio as that which holds with μ_0. The working of casual error may accidently have marred to some extent the true progression of μ_0 or of M. Yet it seems very improbable that the ratio of $\frac{\mu_0}{M}$ is not smaller in the lower than in the higher Galactic latitudes. There seems to be room for the inference that some of the effect on μ_0 may be due to the character of the peculiar motions of the stars themselves as projected on the sky, in consequence of which $\frac{\mu_0}{M}$ varies with the Galactic latitude. For instance, the projected linear motions of the stars on the sky may be actually smaller at low than at high Galactic latitudes. Furthermore variation of the value of μ_1 (the mean proper motion of a single area) is unduly dependent on the larger motions. This is well illustrated in areas 5 and 6 (Table I). For example, in Trapezium 5, $\mu_1 = 2''.43$, only 4 stars out of 79 have proper motions greater than 5″.0. In Trapezium 6, $\mu_1 = 2''.28$, there is only one star among the 48 that has a proper-motion greater than 5″.0; and that one is only 6″.3. It is as if, in the direction of those two areas, there is a comparatively small volume of space near the Sun almost devoid of stars, across which pass the lines of sight toward the background of more distant stars. This might be thought of as an instance of one of those lanes or open spaces which are so characteristic of photographs of the Milky Way.

Nevertheless, this explanation does not seem to help much in accounting for the progression in $M : \mu_0$. Upon this and some analogous points there seems to be an invitation for further research.

CONTENTS.

Precession and Solar Motion. Second Paper. Solution of the Equations, by Lewis Boss.

Editor, Lewis Boss, Albany, N. Y.; Associate Editors: Seth C. Chandler and George W. Hill, Directors of the Gould Fund of the National Academy of Sciences. Published by the Dudley Observatory, Albany, N. Y., U. S. A., to which all communications should be addressed. Price, $5.00 the Volume. Press of Thos. P. Nichols & Sons, Lynn, Mass. *Closed July 2, 1910.*

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MICROMETER MEASURES OF THE FIFTH SATELLITE OF JUPITER AND MISCELLANEOUS OBSERVATIONS OF THE PLANET,

By E. E. BARNARD.

The following observations of the Fifth Satellite of *Jupiter* were made with great difficulty. The satellite was faint and the conditions unfavorable for observing such a difficult object. As usual, the bisections of the planet were made through smoked mica which covered one-half the field. They are a continuation of the measures printed in *A.J.*, 598, and in *A.N.*, 4339. It was not possible to secure more than the two elongations given below. These were obtained graphically by platting the measures.

Elongations of the Fifth Satellite.

East Elongation Time, 1910, March 13^d, 11^h 44^m.3 C.S.T.
East Elongation Time, 1910, March 20^d, 11^h 5^m.7 C.S.T.
East Elongation Distance, 1910, March 13^d = 55″.29, or at ♃, 5.20 = 47″.88.
East Elongation Distance, 1910, March 20^d = 55″.51, or at ♃, 5.20 = 47″.75.

In this connection the following elongations have been deduced from previous measures. Though not perfectly satisfactory they are given here in the hope that they may be useful.

East Elongation Time, 1904, Sept. 3^d, 15^h 10^m.0
East Elongation Time, 1904, Oct. 17, 11 9.0
East Elongation Time, 1904, Oct. 29, 10 5.0
East Elongation Time, 1907, Feb. 5, 11 45±

East Elongation Distance, 1904, Oct. 17 appt. 62″.60 (at ♃, 5.20) 47″.69.
East Elongation Distance, 1906, Dec. 18 appt. 59″.40 (at ♃, 5.20) 47″.86.
East Elongation Distance, 1907, Feb. 5 appt. 56″.25 (at ♃, 5.20) 47″.91.

The following apparent diameters of *Jupiter* have been used to reduce the observations:

1910	Apparent Equatorial	Apparent Polar
	″	″
March 13	44.49	. . .
March 20	44.79	41.99
March 22	44.85	. . .
April 3	44.96	42.14
April 9	44.85	42.04
April 10	. . . .	42.02

On 1910, March 8, the Fourth Satellite passed free of the south limb of the planet. The following measures were made:

12^h 15^m 52^s, distance from south limb, Satellite S 4″.09 (4)
12 18 4, distance from north limb, Satellite S 45.97 (4)

Measures of the Fifth Satellite of *Jupiter*.

1910 *March* 13.

C.S. Time	From Foll. Limb	From Center	Comp.	
h m s	″	″		
11 16 17	31.13	53.37	4	Satellite following.
11 20 47	31.71	53.95	4	
11 24 36	32.03	54.27	4	
11 29 13	32.56	54.81	4	
11 34 46	32.40	54.64	4	
11 40 59	33.17	55.41	4	
11 47 21	32.98	55.22	4	
11 52 15	32.90	55.14	4	
11 58 12	32.52	54.77	5	
12 3 36	31.54	53.77	4	
12 8 31	32.01	54.25	4	
12 13 41	30.29	52.53	4	
12 19 10	30.50	52.75	4	
12 24 44	29.49	51.73	3	
12 28 57	28.24	50.49	4	
12 34 0	28.02	50.26	3	

Satellite faint and excessively difficult.

1910 *March* 20.

C.S. Time	From Foll. Limb	From Center	Comp.	
10 29 42	30.78	53.18	4	Satellite following.
10 32 10	31.04	53.43	4	
10 34 54	31.51	53.90	4	
10 38 3	31.66	54.06	4	
10 40 37	32.11	54.50	4	

1910 *March* 20. — (*Con.*)

C.S Time	From Foll. Limb	From Center	Comp.	
h m s	″	″		
10 43 33	31.96	54.37	4	Satellite following.
10 46 44	32.77	55.17	5	
10 50 36	32.18	54.57	4	
10 53 30	32.37	54.76	4	
10 56 23	32.99	55.38	4	
10 59 14	32.72	55.11	4	
11 2 33	32.96	55.35	4	
11 6 2	33.10	55.50	4	
11 9 4	33.17	55.56	4	
11 11 53	32.99	55.38	4	
11 14 34	32.43	54.82	4	
11 16 36	32.78	55.18	4	
11 19 22	32.35	54.74	4	
11 22 12	32.49	54.89	4	
11 25 44	32.01	54.40	4	
11 28 58	31.46	53.85	4	
11 31 34	31.19	53.58	4	
11 34 58	31.02	53.41	4	
11 39 19	30.41	52.80	5	

Satellite North of Center of Jupiter.

C.S. Time	From Limb	Appt. Lat.	Comp.	
h m s	″	″		
11 45 15	22.66	+1.66	6	from south limb.
11 49 31	20.02	+0.97	6	from north limb.
11 47 23		+1.31	12	
11 54 20	23.25	+2.25	5	from south limb.
11 58 26	19.96	+1.03	5	from north limb.
11 56 23		+1.65	10	
12 3 14	23.17	+2.18	5	from south limb.
12 7 11	19.68	+1.31	5	from north limb.
12 5 13		+1.75	10	

Position-angle of wires 115°.76.

1910 *March* 22.

C.S. Time	From Foll. Limb	From Center	Comp.	
h m s	″	″		
10 23 44	31.05	53.48	4	Satellite following.
10 26 55	32.10	54.52	4	
10 29 12	32.65	55.08	3	
10 31 20	32.23	54.65	4	
10 33 19	32.19	54.61	4	
10 36 34	32.55	54.98	4	
10 39 25	33.05	55.48	4	
10 42 2	32.76	55.18	3	
10 48 36	33.53	55.95	5	
10 56 50	32.75	55.17	5	
11 5 18	32.87	55.30	5	
11 10 37	32.49	54.92	4	
11 17 49	31.27	53.69	5	
11 24 22	30.56	52.99	5	

1910 *April* 3.

C.S. Time	From Foll. Limb	From Center	Comp.	
h m s	″	″		
10 7 34	31.71	54.19	4	Satellite following.
10 11 28	31.65	54.13	4	

Satellite North of Center of Jupiter, April 3.

	From Limb			
h m s	″	″		
10 16 23	22.15	+1.08	6	from south limb.
10 22 4	20.77	+1.30	7	from north limb.
10 19 13		+1.19	13	
10 27 6	22.43	+1.36	6	from south limb.
10 31 47	20.76	+1.31	6	from north limb.
10 29 27		+1.33	12	
10 36 5	22.41	+1.34	5	from south limb.
10 42 41	20.06	+1.02	6	from north limb.
10 39 23		+1.18	11	
10 47 16	22.69	+1.61	5	from south limb.
10 52 29	20.00	+1.07	6	from north limb.
10 49 53		+1.34	11	
11 0 15	23.05	+1.98	7	from south limb.

Position-angle of wires 114°.63.

1910 *April* 9.

	Foll. Limb			
h m s	″	″		
9 18 57	33.47	55.89	4	Satellite following.
9 22 6	33.41	55.83	5	
9 25 16	32.98	55.40	5	
9 28 24	33.15	55.57	5	
9 31 42	33.06	55.48	5	
9 34 47	32.81	55.23	4	
9 37 49	32.35	54.77	5	
9 40 53	32.08	54.50	5	
9 43 57	31.63	54.05	5	
9 47 0	31.65	54.07	4	
9 50 16	31.03	53.45	6	

Satellite North of Center of Jupiter, April 9.

	South Limb		
h m s	″	″	
9 57 29	23.93	2.91	5

Position-angle of wires 116°.43 for polar measures.

1910 *April* 10.

Satellite North of Center of Jupiter.

	From Limb			Satellite following
h m s	″	″		
10 8 8	19.74	1.27	5	from north limb.
10 13 40	22.95	1.94	6	from south limb.
10 10 54		1.61		

Position-angle of wires 114°.96.

In the observations of the polar distances of the satellite on March 20, it will be noticed that the apparent latitudes are discordant, as derived from the north and the south limbs of the planet. I do not understand this. The position angles of the wires remained unchanged during the measures. The polar diameter used is the one previously employed in all my measures of the satellite. The measures themselves would indicate a larger polar diameter: 42″.91. If the latter is used the discordances essentially disappear. Taking the mean, as I have done, however, eliminates the discordance.

MEASURES OF THE POSITIONS OF THE BELTS OF *Jupiter*.

A few measures were made of the position of the belts on the surface of the planet. These are collected below and may be of value sometime. In these measures the apparent polar diameters are given as deduced from the measures; no importance is attached to these, however.

MEASURES OF THE POSITIONS OF THE BELTS OF *Jupiter*.

	Dist. from S. Limb	Comp.	Dist. from N. Limb	Comp.	Apparent Polar Diam.	Comp.	Apparent Latitude	Comp.
1910 JANUARY 8^d 14^h 50^m.								
	″		″		″		″	
North equatorial belt	22.44	1	14.50	1	36.94	2	+ 3.97	2
South equatorial belt	15.58	1	20.54	1	36.12	2	− 2.48	2
Apparent polar diameter					36.53			
1910 FEBRUARY 8^d 14^h 20^m.								
Faint belt south of equator	11.65	2	27.90	2	39.55	4	− 8.13	4
South edge of south equatorial belt	14.20	2	25.12	2	39.32	4	− 5.46	4
North edge of south equatorial belt	18.57	2	21.56	2	40.13	4	− 1.49	4
South edge of north equatorial belt	22.03	2	16.85	2	38.88	4	+ 2.59	4
North edge of north equatorial belt	25.01	3	14.67	2	39.68	5	+ 5.17	5
Apparent polar diameter					39.52			
1910 JUNE 12^d 8^h 0^m.								
North equatorial belt	21.31	2	15.22	2	36.53	4	+ 3.05	4
South equatorial belt	15.95	2	20.75	2	36.70	4	− 2.40	4
Thin belt	13.43	2	23.20	2	36.63	4	− 4.89	4
Thin belt	11.09	2	25.96	2	37.05	4	− 7.43	4
Faint thin belt	6.99	2	30.62	2	37.61	4	− 11.81	4
Faint thin belt north	26.77	2	9.83	2	36.60	4	+ 8.47	4
Apparent polar diameter					36.85			
1910 JULY 5^d 8^h 0^m.								
Partial belt or edge of polar cap	7.20	2	27.02	2	34.22	4	− 9.91	4
Narrow belt	10.16	2	24.76	2	34.92	4	− 7.30	4
South edge of south belt	12.69	2	21.71	2	34.40	4	− 4.51	4
North edge of south belt	15.87	2	18.55	2	34.42	4	− 1.34	4
Narrow belt in position of n. equatorial belt	20.75	3	14.15	2	34.90	5	+ 3.30	4
Fragment of dark belt or edge of n. polar cap	27.85	2	6.25	2	34.10	4	+ 10.80	4
Apparent polar diameter					34.51			

Between the last object measured and the north limb was an irregular, dark marking.

POSITION ANGLES OF THE BELTS OF *Jupiter*.

These, which are given below, are a continuation of those printed in *A.J.*, 598, and previous numbers, and also in *A.N.*, 4339.

		C.S. Time		P.A.	Comp.	
		h	m	°		
Jan.	8	14	40	115.21	6	Seeing excessively bad.
Feb.	5	14	15	115.29	6	Seeing excessively bad.
	8	14	5	116.23	5	
	12	14	55	117.69	5	Seeing very bad.
	27	13	35	116.25	5	Hazy sky.
Mar.	1	13	0	115.82	5	
	5	12	30	116.52	5	Seeing excessively bad.
	8	12	10	115.84	5	
	12	12	50	116.81	5	Seeing excessively bad.
Mar.	13	11	0	116.36	5	Seeing good.
	15	12	45	116.17	5	
	19	13	55	115.78	5	
	20	10	25	115.76	5	Seeing poor.
	22	10	20	116.05	5	Seeing good.
Apr.	2	11	20	117.20	7	Very blurred through clouds
	3	11	10	115.72	6	Seeing good.
	10	10	15	115.80	5	Seeing good.
	12	8	25	115.93	5	Seeing excessively bad.
	19	7	50	115.89	5	Through clouds.
June	12	8	0	116.34	5	Seeing good.
July	3*	10	0	113.51	3	Only feeblest traces of belts.
	5	7	50	116.59	5	Seeing good.

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* Reject.

Yerkes Observatory, Williams Bay, Wis., 1910 *July* 9.

OCCULTATIONS OF STARS BY THE MOON,

OBSERVED AT THE VASSAR COLLEGE OBSERVATORY WITH THE 12-INCH TELESCOPE.

[Communicated by the Director, MARY W. WHITNEY.]

Date	Star	Immersion	Emersion	Observer	
		Gr.M.T. h m s	Gr.M.T. h m s		
1909 Oct. 20	σ *Sagittarii*	12 11 48.2[1]	13 7 41.2[2]	[1] P. R. SUTTON.	[2] M. RENNER.
1909 Nov. 26	BD 20°715	20 31 48.6	20 56 16.8	C. E. FURNESS.	
	BD 20°716	20 49 34.3[1]	21 28 27.4[2]	[1] C. E. FURNESS.	[2] M. W. WHITNEY.
	BD 20°719	21 37 13.5		C. E. FURNESS.	After totality. Moon getting bright.
	BD 20°721	21 51 4.4		C. E. FURNESS.	

COMPARISON OF THE STANDARD CATALOGUES OF AUWERS AND BOSS FOR 1910.

By BENJAMIN BOSS.

The following comparison between the new fundamental system of AUWERS as contained in the *Berliner Jahrbuch*, and that of BOSS contained in the "*Preliminary General Catalogue* of 6188 *Stars for the Epoch* 1900," is very instructive as showing the degree of similarity of results for the position of standard stars obtained from nearly the same material worked up along somewhat different lines.

No comparison was made with the fundamental system by NEWCOMB, given in the "*Catalogue of Fundamental Stars for* 1875 *and* 1900," because this catalogue, published as it was in 1898, did not have the advantage of the later material used in the two other catalogues, and consequently individual stars require a considerable correction in the direction indicated by AUWERS and BOSS.

COMPARISON OF RIGHT-ASCENSIONS.

Tables I and II of $\Delta\alpha_\alpha$ and 100 $\Delta\mu_\alpha$ were obtained by subtraction, $B-A$, and corrected for the equinoctial constant difference, for $\Delta\alpha_\delta$, and for $\Delta\alpha_M$. They show the systematic differences in right-ascension that vary in the order of right-ascension, for the several zones as indicated. In obtaining these results use was made of the individual weights of the stars as contained in the *Preliminary General Catalogue*. The comparisons throughout this article are for the epoch 1910.

TABLE I. OBSERVED $\Delta\alpha_\alpha$. $B-A$.

	+90° to +55°	+55° to +30°	+30° to −20°	−20° to −50°	−50° to −90°
h	s	s	s	s	s
0	−.002	−.008	+.001	+.016	−.001
1	+.001	+.006	+.007	+.027	.000
2	+.004	+.005	+.008	+.012	−.008
3	+.003	+.002	+.004	+.016	+.028
4	+.006	+.004	−.001	−.009	.000
5	+.006	−.002	.000	−.010	−.022
6	+.005	+.004	−.003	−.004	.000
7	+.002	.000	−.004	−.007	−.020
8	.000	+.003	.000	−.007	−.006
9	.000	+.004	−.002	−.010	−.007
10	+.004	−.001	−.001	−.001	−.010
11	+.001	.000	+.001	−.001	+.003
12	−.002	−.003	+.001	+.006	−.004
13	+.002	+.002	+.001	−.003	−.001
14	−.002	−.003	+.001	.000	+.006
15	−.005	.000	+.004	−.013	+.005
16	+.003	+.001	−.001	−.001	+.012
17	−.003	−.002	−.002	+.008	−.004
18	−.002	+.001	+.001	−.004	+.018
19	−.006	+.001	+.001	−.003	+.009
20	+.002	−.001	−.001	+.010	−.002
21	−.004	−.008	−.002	−.001	+.004
22	−.006	−.004	−.004	−.001	+.005
23	−.003	−.002	+.001	+.003	+.016

These quantities are to be multiplied by sec δ.

Table II. Observed 100 $\Delta\mu_a$. $B-A$.

h	+90° to +55° s	+55° to +30° s	+30° to −20° s	−20° to −50° s	−50° to −90° s
0	.000	−.022	−.001	+.008	+.009
1	+.004	−.005	+.021	−.026	−.030
2	+.005	+.008	+.025	+.046	−.027
3	+.002	−.002	+.011	+.068	+.063
4	+.003	+.007	.000	−.009	−.014
5	+.009	−.015	−.004	−.035	−.047
6	+.013	+.003	−.019	−.023	+.018
7	+.005	−.012	−.020	−.022	−.035
8	+.011	+.005	−.004	−.036	−.021
9	+.003	+.009	−.010	−.020	−.020
10	+.007	−.003	−.001	+.002	−.031
11	+.001	+.005	+.004	−.005	+.003
12	−.009	−.006	+.005	+.018	−.016
13	+.008	+.001	−.005	−.019	−.005
14	− 004	−.001	−.002	−.018	+.004
15	−.006	−.008	+.002	−.028	+.008
16	+.005	.000	−.007	+.002	+.024
17	+.001	−.003	−.007	+.025	−.009
18	−.003	+.003	+.004	−.004	+.043
19	− 010	+.006	+.010	+.005	+.027
20	+.002	−.004	+.006	+.052	−.005
21	−.008	−.012	+.001	+.009	+.012
22	−.017	−.003	−.002	+.008	+.009
23	−.012	−.009	−.005	+.007	+.037

These quantities are to be multiplied by see δ.

In Tables I and II the differences $\Delta\alpha_a$ and 100 $\Delta\mu_a$ may be assumed to follow the sine-cosine form. Including the constant equinox correction of $-^{s}.003$, the expressions for the various zones become:

Formulated $\Delta\alpha_a$; $B-A$.

° °	s s s
+90 to +55	$-.003 + (+.003 \sin\alpha - .001 \cos\alpha) \sec\delta$
+55 to +30	$-.003 + (+.003 \sin\alpha + .000 \cos\alpha) \sec\delta$
+30 to −20	$-.003 + (+.000 \sin\alpha + .001 \cos\alpha)$
−20 to −50	$-.003 + (-.001 \sin\alpha + .008 \cos\alpha) \sec\delta$
−50 to −90	$-.003 + (-.007 \sin\alpha + .004 \cos\alpha) \sec\delta$

Adopted $\Delta\alpha_a$; $B-A$.

° °	s s
+90 to +30	$\boldsymbol{-.003 + .003 \sin\alpha \sec\delta}$
+30 to −20	$\boldsymbol{-.003}$
−20 to −90	$\boldsymbol{-.003 + (-.004 \sin\alpha + .006 \cos\alpha) \sec\delta}$

Formulated 100 $\Delta\mu_a$; $B-A$.

° °	s s s
+90 to +55	$-.005 + (+.006 \sin\alpha - .002 \cos\alpha) \sec\delta$
+55 to +30	$-.005 + (+.002 \sin\alpha - .003 \cos\alpha) \sec\delta$
+30 to −20	$-.005 + (-.003 \sin\alpha + .005 \cos\alpha)$
−20 to −50	$-.005 + (-.009 \sin\alpha + .014 \cos\alpha) \sec\delta$
−50 to −90	$-.005 + (-.018 \sin\alpha + .011 \cos\alpha) \sec\delta$

Adopted 100 $\Delta\mu_a$; $B-A$.

° °	s s s
+90 to +30	$\boldsymbol{-.005 + (+.004 \sin\alpha - .003 \cos\alpha) \sec\delta}$
+30 to −20	$\boldsymbol{-.005 + (-.003 \sin\alpha + .005 \cos\alpha)}$
−20 to −90	$\boldsymbol{-.005 + (-.014 \sin\alpha + .013 \cos\alpha) \sec\delta}$

We next examine the terms $\Delta\alpha_\delta$ and 100 $\Delta\mu_\delta$ presented in Table III.

Here the agreement seems very good except between −25° and −55°. All authorities have had trouble in fixing the meridian between these limits. For about 1845 $B-A$, in $\Delta\alpha_\delta$ and within these limits, is practically a negligible quantity. The virtual explanation of this appears in *A.J.*, 499, Vol. XXI, p. 151.

Since the *Preliminary General Catalogue* by Boss was completed, there has been published in the *Astronomische Beobachtungen*, Königsberg, Abth. 42, a series of right-ascensions by Dr. Fritz Cohn. The registering micrometer by Repsold was employed. Extensive comparisons with the standard catalogues appear in the Introduction, from which I extract the following:

$C-B$; $\Delta\alpha_\delta$.

°	s	°	s
+35	−.006	− 5	+.002
+30	−.003	−10	.000
+25	−.001	−15	−.002
+20	.000	−20	−.002
+15	+.001	−22	−.002
+10	+.002	−24	−.003
+ 5	+.003	−26	−.003
0	+.003	−28	−.003

The registering micrometer is supposed to secure comparative immunity from systematic errors arising from personal equation, and there is much in experience to support this view. The agreement of Cohn's observations with those of the Boss system, adds very material testimony to the accuracy of the latter system as to $\Delta\alpha_\delta$.

Table III. Systematic Differences ; $B-A$, Order of Declination. $\Delta\alpha_\delta$ and 100 μ_δ.

	Observed Diff.			Adopted	
	$\Delta\alpha_\delta$	100 $\Delta\mu_\delta$		$\Delta\alpha_\delta$	100 $\Delta\mu_\delta$
°	s	s	°	s	s
+87	+.043	.000	+85	+.046	+.072
80	+.044	+.110	80	+.047	+.108
75	+.044	+.112	75	+.037	+.101
70	+.020	+.061	70	+.027	+.082
65	+.016	+.058	65	+.017	+.059
+60	+.009	+.033	+60	+.009	+.037
55	+.002	+.020	55	+.002	+.016
50	−.004	−.003	50	−.004	−.003
45	−.008	−.018	45	−.006	−.012
40	−.007	−.021	40	−.006	−.014
35	−.001	−.008	35	−.005	−.014
+29	−.003	−.009	+30	−.003	−.011
25	−.001	−.009	25	−.001	−.008
20	−.001	−.006	20	−.001	−.006
15	.000	−.007	15	.000	−.004
10	.000	+.002	10	.000	−.002
+ 5	−.001	−.001	+ 5	.000	−.001
0	+.001	+.004	0	.000	+.001
− 5	−.002	−.002	− 5	.000	+.003
10	.000	+.004	10	.000	+.005
15	+.002	+.010	15	+.002	+.009
21	+.006	+.015	20	+.008	+.015
25	+.019	+.026	25	+.020	+.023
−30	+.034	+.035	−30	+.034	+.039
35	+.051	+.078	35	+.051	+.075
40	+.070	+.128	40	+.066	+.128
45	+.058	+.093	45	+.057	+.096
50	+.043	+.072	50	+.046	+.072
55	+.037	+.073	55	+.033	+.054
−60	+.012	+.003	−60	+.018	+.035
65	+.010	−.029	65	+.003	+.013
70	+.005	−.006	70	−.011	−.013
75	−.010	+.004	75	−.024	−.048
80	−.050	−.161	80	−.039	−.111
−87	−.059	−.344	−85	−.071	−.287

Absolute Magnitude-Equation.

The right-ascensions in the *P.G.C.* are supposed to have been freed from the effects of magnitude-equation by the application of systematic corrections for that effect. Thus we may suppose that the larger part of the differences, $B-A$, in $\Delta\alpha_{\mathrm{M}}$ consists of the magnitude-equation for the system of Auwers. In the preliminary operations of this comparison, the magnitude-equation for Auwers' system deduced by Cohn on p. 42 of *Königsberg Beobachtungen,* Abth. 42, was used as a preliminary approximation to $\Delta\alpha_{\mathrm{M}}$ for $B-A$, and later a differential correction to the preliminary value was computed.

Preliminary $\Delta\alpha_{\mathrm{M}}$; Unit $0^{s}.001$.

	C − A		C − A		C − A
M		M		M	
1.0	+19.6	3.0	+ 6.4	5.0	− 5.9
1.5	+16.3	3.5	+ 3.1	5.5	− 8.6
2.0	+13.0	4.0	− 0.2	6.0	−11.3
2.5	+ 9.7	4.5	− 3.2	6.5	−14.0

After thus freeing the residuals $B-A$ from the effects of preliminary $\Delta\alpha_{\mathrm{M}}$, together with the effects of $\Delta\alpha_\alpha$ and $\Delta\alpha_\delta$, the following differential corrections to preliminary $\Delta\alpha_{\mathrm{M}}$ were obtained:

		No. **
M	s	
2.0	0.000	50
3.0	.000	129
4.0	−.001	245
5.0	.000	130
6.0	.000	78
7.0	+.001	235

The magnitudes are taken from the *P.G.C.*

The foregoing table in its derivation simply means the difference: Cohn − *P.G.C.* as to magnitude-equation, and the group $7^{\mathrm{M}}.0$ was, therefore, derived directly through comparison of *P.G.C.* with Cohn's Zodiacal Catalogue. As already shown, $C-A$ and $B-A$ are identical as to $\Delta\alpha_{\mathrm{M}}$; so that for $B-A$, preliminary $\Delta\alpha_{\mathrm{M}}$ becomes adopted $\Delta\alpha_{\mathrm{M}}$, and we have:

$$\boldsymbol{\Delta\alpha_{\mathrm{M}}\ (\text{for } B-A) = -{}^{s}.0062\ (M-3.5)}$$

where M is the magnitude on the scale adopted in *P.G.C.*

Thus the above table implies that no correction is indicated for the *P.G.C.* on account of magnitude-equation.

In fact we are led to the same conclusion by the table of $\Delta\alpha_{\mathrm{M}}$ deduced by Cohn, on p. 41, of the Konigsberg publication No. 42, in which Cohn derives the following values: Cohn − 627 *Principal Standard Stars,* indicated under the head of $C-B'$ in the following table:

	C − B′	B′ − B	C − B	Corrected $\Delta\alpha_{\mathrm{M}}$
M	s	s	s	
0.9	+.025	−.020	+.005	+.001
2.1	+.010	−.011	−.001	−.005
2.8	+.006	−.005	+.001	−.003
3.3	+.006	−.002	+.004	.000
3.8	−.000	+.002	+.002	−.002
4.3	−.002	+.006	+.004	.000
4.8	−.006	+.010	+.004	.000
5.3	−.006	+.014	+.008	+.004
5.8	−.011	+.018	+.007	+.003
6.4	−.018	+.022	+.004	.000

It will be remembered that Boss' Catalogue of "627 *Principal Standard Stars*" was not corrected for the effect of magnitude, but that its magnitude-equation was found to be $-0^{s}.0077\ (M-3.5)$; where M is estimated on Pogson's scale. This correction is incorporated under the heading "$B'-B$" in the above table. "$C-B$" represents then the comparison of the Boss system, corrected for magnitude, with Cohn's observations. This comparison introduces a constant of $+{}^{s}.004$ (equatorial $\Delta\alpha_\alpha$ of $B-A$) which has been taken out in the column headed "Corrected $\Delta\alpha_{\mathrm{M}}$."

The slight difference between these values, and those deduced previously in this article, arises partly from some revisions incorporated in the *P.G.C.*, not taken account of in the "627 *Principal Standard Stars*," and partly because nearly three times as many stars are used in the present comparison.

COMPARISON OF DECLINATIONS.

In the declinations the agreement is very fair excepting for the far southern zones. The systematic differences there, chiefly in the proper motions, is probably largely due to the revision of HENDERSON'S Cape '33 observations by BOSS. See *A.J.*, Vol. XXIII, Nos. 540-541.

The results of observed $\Delta\delta_a$ and 100 $\Delta\mu'_a$ are given in Tables IV and V respectively.

TABLE IV. OBSERVED $\Delta\delta_a$; $B-A$.

	+90° to +55°	+55° to +30°	+30° to −20°	−20° to −50°	−50° to −90°
h	″	″	″	″	″
0	+.13	+.20	+.12	+.26	+.23
1	+.10	+.03	+.11	+.14	+.26
2	+.06	+.14	+.10	+.24	+.26
3	−.14	−.03	+.08	+.27	+.09
4	+.09	+.06	+.07	−.03	+.09
5	+.03	+.05	+.08	+.02	−.24
6	−.11	+.02	+.03	+.02	−.06
7	+.14	+.10	−.01	−.04	−.17
8	−.05	−.06	−.04	−.04	−.34
9	.00	+.03	.00	−.27	−.29
10	−.18	.00	−.05	−.34	−.29
11	−.02	−.06	−.09	−.04	−.42
12	−.01	+.01	−.07	+.11	−.10
13	−.06	−.16	−.05	+.12	−.18
14	−.09	−.02	−.03	+.06	−.12
15	−.12	.00	.00	+.18	+.08
16	−.06	−.13	−.05	+.10	+.22
17	−.09	−.10	−.06	−.10	+.23
18	−.02	−.03	−.03	.00	−.12
19	+.04	−.02	−.07	−.04	+.10
20	−.02	−.03	−.12	−.16	−.11
21	+.06	−.02	−.03	−.04	+.07
22	+.05	+.02	+.02	+.11	+.22
23	+.12	−.02	+.03	+.02	+.08

TABLE V. OBSERVED 100 $\Delta\mu'_a$; $B-A$.

	+90° to +55°	+55° to +30°	+30° to −20°	−20° to −50°	−50° to −90°
h	″	″	″	″	″
0	+.14	+.42	+.21	+.42	+.46
1	+.11	−.04	+.22	+.20	+.66
2	+.03	+.10	+.20	+.65	+.50
3	−.42	−.11	+.11	+.79	+.18
4	+.32	+.17	+.12	−.08	+.24
5	−.07	+.05	+.15	−.03	−.57
6	−.35	+.10	+.03	+.05	+.11
7	+.22	+.28	−.10	−.04	−.17
8	−.36	−.08	−.03	+.04	−.77
9	−.20	+.09	−.08	−.50	−.61
10	−.29	+.06	−.18	−.95	−.60
11	+.03	−.05	−.27	−.12	−.90
12	−.04	+.11	−.15	+.20	−.38
13	−.06	−.26	−.08	+.13	−.52
14	−.15	+.05	−.02	+.07	−.16
15	−.23	+.12	+.05	+.36	+.08
16	−.04	−.22	−.02	+.26	+.40
17	−.30	−.12	−.12	−.20	+.54
18	−.05	+.07	+.03	−.12	−.39
19	+.24	.00	−.06	−.10	+.45
20	−.01	+.10	−.22	−.37	−.31
21	+.14	−.03	−.09	−.07	+.26
22	+.19	+.03	+.01	+.19	+.67
23	+.27	−.07	+.01	+.02	+.22

From Tables IV and V the following systematic terms are deduced:

$\Delta\delta_\alpha$; $B-A$.

		Wt.
° °	″ ″	
+90 to +55	$+.02 \sin\alpha + .08 \cos\alpha$	1
+55 to +30	$+.04 \sin\alpha + .03 \cos\alpha$	1
+30 to −20	$+.05 \sin\alpha + .05 \cos\alpha$	2
−20 to −50	$-.01 \sin\alpha + .05 \cos\alpha$	1
−50 to −90	$-.12 \sin\alpha + .20 \cos\alpha$	1

ADOPTED $\Delta\delta_\alpha$; $B-A$.

° °	″ ″
+90 to −20	$\mathbf{+.04 \sin\alpha + .05 \cos\alpha}$
−20 to −90	$\mathbf{-.06 \sin\alpha + .12 \cos\alpha}$

100 $\Delta\mu'_\alpha$; $B-A$.

		Wt.
° °	″ ″	
+90 to +55	$-.03 \sin\alpha + .14 \cos\alpha$	1
+55 to +30	$+.06 \sin\alpha \quad .00 \cos\alpha$	1
+30 to −20	$+.05 \sin\alpha + .11 \cos\alpha$	2
−20 to −50	$\left\{\begin{array}{l} -.02 \sin\alpha + .12 \cos\alpha \\ +.30 \sin 2\alpha + .11 \cos 2\alpha \end{array}\right\}$	1
−50 to −90	$\left\{\begin{array}{l} -.25 \sin\alpha + .49 \cos\alpha \\ +.22 \sin 2\alpha + .11 \cos 2\alpha \end{array}\right\}$	1

ADOPTED 100 $\Delta\mu'_\alpha$; $B-A$.

° °	″ ″
+90 to −20	$\mathbf{+.03 \sin\alpha + .09 \cos\alpha}$
−20 to −90	$\left\{\begin{array}{l} \mathbf{-.13 \sin\alpha + .31 \cos\alpha} \\ \mathbf{+.26 \sin 2\alpha + .11 \cos 2\alpha} \end{array}\right\}$

Table VI contains observed and adopted $\Delta\delta_\delta$ and 100 $\Delta\mu'_\delta$.

In the latest system of AUWERS in declination, the declinations of BRADLEY received no weight in the absolute sense. The agreement between the two systems in $\Delta\delta_\delta$ is now excellent, although a slight differential effect in the bad portion of BRADLEY's quadrant is still felt in the region +20° to +45°.

The earliest effective epoch in the declinations of the southern hemisphere south of −40°, where the discordance in 100 $\Delta\mu'_\delta$ is greatest, is 1833, and the latest epoch is about 1890. We have very fair agreement about 1885, and the greatest discordance during the period of observation is 1833. From the discussion of HENDERSON's declinations for 1833, *Ast. Jour.*, Vol. XXIII, p. 120, the declinations of that catalogue were very seriously modified before they were employed in forming Boss' system in declination. It is this procedure that is principally responsible for the discordance in B−A for 100 $\Delta\mu'_\delta$ between −40° and −75°.

TABLE VI. SYSTEMATIC DIFFERENCES ; $B-A$,

ORDER OF DECLINATION. $\Delta\delta_\delta$ AND 100μ'_δ.

Observed Diff.			Adopted		
	$\Delta\delta_\delta$	100 $\Delta\mu'_\delta$		$\Delta\delta_\delta$	100 $\Delta\mu'_\delta$
°	″	″	°	″	″
			+90	−.13	−.42
+87	−.11	−.32	85	−.09	−.30
80	−.09	−.36	80	−.07	−.20
75	−.02	−.13	75	−.05	−.14
70	−.01	−.10	70	−.04	−.11
65	−.06	−.13	65	−.04	−.13
+60	−.05	−.20	+60	−.05	−.18
55	−.07	−.17	55	−.06	−.16
50	−.08	−.12	50	−.08	−.11
45	−.06	−.01	45	−.12	−.21
40	−.23	−.32	40	−.20	−.32
35	−.29	−.46	35	−.27	−.39
+29	−.21	−.20	+30	−.28	−.42
25	−.27	−.42	25	−.26	−.40
20	−.24	−.38	20	−.23	−.32
15	−.17	−.19	15	−.19	−.20
10	−.16	−.12	10	−.15	−.12
+ 5	−.15	−.08	+ 5	−.12	−.06
0	−.09	−.01	0	−.09	−.04
− 5	−.09	−.03	− 5	−.10	−.05
10	−.15	−.17	10	−.15	−.09
15	−.15	−.29	15	−.14	−.17
21	−.06	−.20	20	−.07	−.26
25	−.04	−.24	25	−.05	−.27
−30	−.08	−.20	−30	−.08	−.22
35	−.15	−.18	35	−.13	−.13
40	−.17	−.29	40	−.16	+.01
45	−.01	+.46	45	−.15	+.18
50	.00	+.59	50	−.11	+.36
55	−.19	+.23	55	−.05	+.55
−60	+.01	+.59	−60	+.04	+.73
65	+.18	+1.01	65	+.18	+.91
70	+.25	+1.00	70	+.25	+.89
75	−.03	−.02	75	+.10	+.33
80	+.04	+.03	80	−.03	−.08
−87	−.16	−.51	85	−.13	−.31
			−90	−.19	−.49

After correcting the residual differences, $B-A$, for systematic differences, there remain remarkably few cases of large outstanding residuals. This should not only indicate great accuracy in the numerical work on the catalogues, but should also inspire greater confidence in the reality of the systematic differences.

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THE HOOD OF A COMET'S HEAD,

By PERCIVAL LOWELL.

As a comet approaches the Sun envelops are seen to be thrust sunward from the head. Of these envelops several are successively given off, two or three of which are often simultaneously visible. They are undoubtedly caused by the heating the comet experiences as it nears our luminary, which sets up electrical action resulting in something akin to explosion in the nucleus. These envelops have been most recently observed in the case of HALLEY'S Comet.

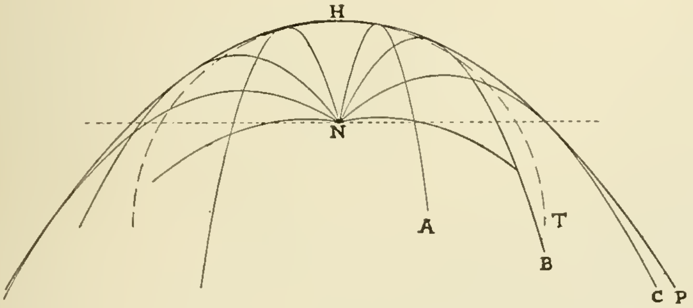


FIG. I. NA, NB, NC are the parabolic paths of individual particles, all ejected from the nucleus, N, with the same velocity, v, but at different angles of projection, φ.
HP is their eventual envelop, a parabola with N for focus.
HT is the equal time envelop of particles ejected simultaneously, from the nucleus of which the one vertically projected has just reached H.

It is interesting to examine mathematically the form such hoods should take under the forces apparently at work and then to compare the theoretic results with the observed facts.

The forces acting on the particles are an ejective force from the nucleus and a repulsive force directed from the Sun. We may conveniently take the comet's nucleus for origin and a line joining that nucleus with the Sun for our axis of y. As the action throughout the head is rapid, we may neglect the orbital motion of the comet because it affects all the particles equally and is therefore for our present purpose eliminable. Furthermore as the distance of the nucleus from the edge of the hood is very small compared with the distance to the Sun we may regard the repellant force as constant throughout the space considered and to act in the same direction everywhere. It will be perceived, then, that to the first order of small quantities we have a problem in motion similar to that of a projectile on the Earth's surface: the initial throw corresponding to the force of the nuclear emission while the solar repulsion counterparts gravity. The path of any eject with reference to the nucleus is therefore a parabola. It is true that with projectiles from the Earth the path is really part of an ellipse, while with the particles thrown out by the comet it is part of an hyperbola, but in both cases the resulting relative orbit is sensibly parabolic.

We proceed, therefore, in a manner already known for projectiles supposed discharged in vacuo. We shall assume, to start with, that the particles on the sunward side of the nucleus are ejected with the same velocity, v, at all angles — and we must determine first the extreme range a particle may have in a given direction r making an angle θ with the line to the Sun. The range will vary according to the angle φ which the direction of any projection makes with the axis of y.

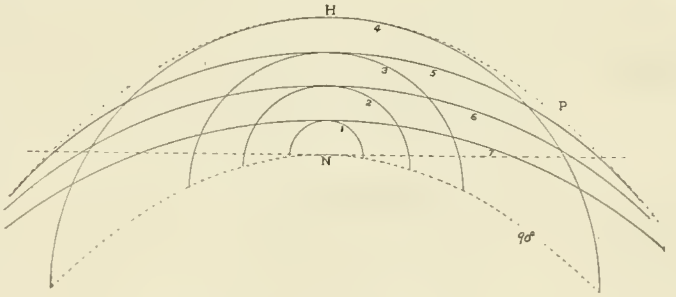


FIG. II. N as before represents the nucleus.
The velocity of ejection is as in Fig. I the same at all angles.
1, 2, 3, 4 are the equal time envelops of simultaneously ejected particles on the way out to H.
5, 6, 7 the similar envelops of the particles on their way back to form the tail.

The coordinates of any eject at the time t are:

$$x = v \sin \varphi \,.\, t \qquad y = v \cos \varphi \,.\, t - \tfrac{1}{2} f t^2 \qquad (1)$$

where v is the velocity of ejection and f the repellant force of the Sun.

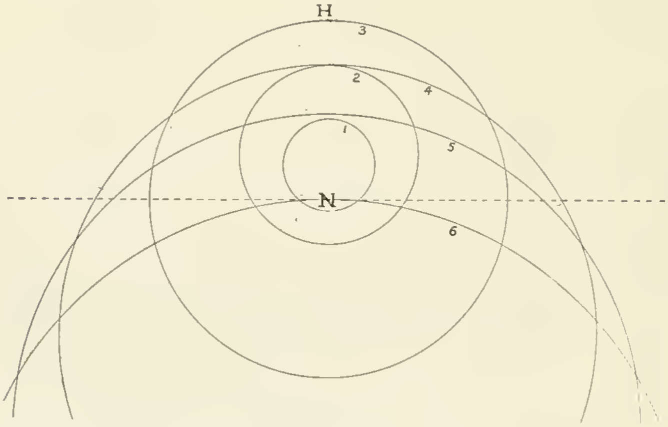


FIG. III. N as before is the nucleus.
The velocity of the ejected particles is here as $v \cos \varphi$.
1, 2, 3 represents as in Fig. II the time envelops out; 4, 5, 6 the time envelops in.

Also $x = r \sin \theta \qquad y = r \cos \theta$
where r, θ are the polar coordinates of the particle reckoned from the direction to the Sun.

Eliminating t from (1) and substituting polar coordinates for cartesian ones we get

$$r \cos \theta = r \cot \varphi \sin \theta - \frac{f r^2 \sin^2 \theta}{2 v^2 \sin^2 \varphi}$$

whence
$$r = \frac{2 v^2 \sin \varphi \,.\, \sin (\theta - \varphi)}{f \sin^2 \theta} \,. \qquad (2)$$

For a given angle θ the range, r, will be a maximum when $2 \sin \varphi \,.\, \sin (\theta - \varphi)$ is a maximum.

Developing and reducing, remembering that

$$2 \sin^2 \varphi = 1 - \cos 2 \varphi$$

we get

$$\begin{aligned} 2 \sin \varphi \,.\, \sin (\theta - \varphi) &= \sin 2 \varphi \,.\, \sin \theta + \cos 2 \varphi \,.\, \cos \theta - \cos \theta \\ &= \cos (2 \varphi - \theta) - \cos \theta \,. \end{aligned}$$

For this to be a maximum

$$\frac{d \left[\cos (2 \varphi - \theta) - \cos \theta \right]}{d \varphi} = - 2 \sin (2 \varphi - \theta) = 0$$

whence
$$\tan 2 \varphi = \tan \theta$$
or
$$\varphi = \tfrac{1}{2} \theta \,.$$

Thus for the range to be a maximum the angle of projection must halve the angle between the Sun and r.

Incidentally we notice that since the direction of projection is tangent to the parabola at the point and by a well-known property of the curve, the tangent makes equal angles with the axis and the radius vector, r, must pass through the focus in each trajectory.

Lowell Observatory P. L.

1. DRAWING, MAY 24, 8h 30m±

Substituting $\varphi = \frac{1}{2}\theta$ in (2) we have

$$r = \frac{2\,v^2 \sin^2 \frac{1}{2}\theta}{f \sin^2 \theta}$$

$$= \frac{v^2}{f} \cdot \frac{1 - \cos\theta}{1 - \cos^2\theta} = \frac{v^2}{f(1 + \cos\theta)}\,.$$

This is the focal equation of a parabola whose focus is the nucleus of the comet and whose semi-latus rectum is $\frac{v^2}{f}$.

Lowell Observatory. *P. L.*

II. Drawing, May 30, $8^h\ 42^m$.

The envelop, therefore, of the maximum range for all particles ejected from the nucleus is a parabola whose vertex is the sunward edge of the hood at a distance $\frac{v^2}{2f}$ from the nucleus.

The time of flight, however, differs for each particle according to the direction of the range. Simultaneously ejected particles, therefore, will not reach the boundary of the enveloping parabola together. Supposing still the velocity of ejection, v, to be the same in all directions, let us find the enveloping curve in this case.

Making the time a constant we have

$$x = v\,.\sin\varphi\,.\,c \qquad y = v\cos\varphi\,.\,c - \tfrac{1}{2}fc^2$$
$$r^2 = x^2 + y^2 = v^2c^2 - vfc^3\cos\varphi + \tfrac{1}{4}f^2c^4$$
$$y = r\cos\theta = v\cos\varphi\,.\,c - \tfrac{1}{2}fc^2$$

whence $\quad vc\cos\varphi = r\cos\theta + \frac{1}{2}fc^2$

and $\quad r^2 = v^2c^2 - fc^2\,r\cos\theta - \frac{1}{4}f^2c^4\,.$

This is the equation of a circle of radius vc with the nucleus of the comet at a distance $\frac{1}{2}fc^2$ from its centre.

Such, then, is the curve which would be shown at any time, c, by particles thrown out from the nucleus by an explosion, supposing the velocity of ejection the same for all.

The centre of the circle starts at the nucleus and retreats away from the Sun as time goes on, in such a manner that its widening periphery has always for envelop the enveloping parabola.

Suppose the velocity of ejection not to be the same in all directions. If the body were a solid sphere the heating of its surface would be as the cosine of the angle from the Sun. As the kinetic energy of the molecules is $\frac{1}{2}mv^2$ we may perhaps take the velocity of ejection as $\sqrt{\cos\varphi}$. The body is not solid but it would seem as if $v_1 = v\cos\varphi$ would certainly be a limiting value.

Suppose therefore $\qquad v_1 = v\cos\varphi$

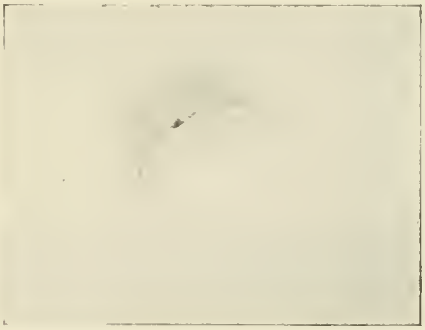
then $\quad x = vc\sin\varphi\cos\varphi \quad y = vc\cos^2\varphi - \frac{1}{2}c^2f = r\cos\theta$

$$r^2 = x^2 + y^2 = v^2c^2\cos^2\varphi - vc^3f\cos^2\varphi + \tfrac{1}{4}c^4f^2$$
$$= (vc - c^2f)\cos\theta + \tfrac{1}{2}vc^3f - \tfrac{1}{4}c^4f^2$$
$$= \tfrac{1}{4}v^2c^2 + (vc - c^2f)\,r\cos\theta - [\tfrac{1}{2}(vc - c^2f)\,]^2$$

which represents a circle whose radius is $\frac{1}{2}vc$ and the distance from the origin to its centre, $-\frac{1}{2}(vc - c^2f)$.

For an explosive action from the nucleus the limiting value would therefore both be eccentric circles and from the general look of the curves it would seem that in both cases their envelops would be parabolas.

We may now compare these curves with the observed facts in the case of Halley's Comet at its last apparition. We notice at once a general resemblance. The outer edge of the head and of the beginning of the tail has the appearance of a parabola when the head is devoid of visible successive envelops while when these are present they show in a general way the outlines of circles. This will be seen in the two drawings of the head of Halley's Comet made by the writer — before the mathematical investigation was begun.



Lowell Observatory. *P. L.*

III. Drawing, June 1.

From these drawings it appears that the successive hoods are visible on their journey out sunward rather than on their fall back. This is what we should expect from the resistance they must suffer from the matter composing the head, the action of which would gradually disintegrate their form into indistinguishability. This deduction is interesting and may with safety be prophesied to be found on investigation to be consonant with fact.

The investigation has been made for a plane. But it is evident from the symmetry of the action that the result would be true in any plane. It is also clear that the particles would be most crowded together near the outer edge of the parabola in any plane and that the effect of all the planes together would tend in the same direction. As for the dark streak seen in comets following the nucleus, the nucleus would itself stop any particles travelling directly back and so keep a lane open behind it.

In the preparation of this paper I am indebted to my assistant Miss WILLIAMS for much of importance.

Boston, 1910 *July* 19.

PERTURBATIONS OF HALLEY'S COMET DUE TO THE ACTION OF *VENUS* AND THE EARTH.

By R. T. CRAWFORD and W. F. MEYER.

As it will be several weeks before an orbit of a semidefinitive character, based upon observations made at this apparition of HALLEY'S Comet, can be issued from this Department, it is thought advisable to publish, at this time, the perturbations of the comet due to the action of *Venus* and the Earth, that others may make such use of them as they may desire.

The masses adopted in this work are

$$\text{for } Venus\ ; \quad \frac{1}{m} = 406{,}600$$

$$\text{for Earth-Moon}\ ; \quad \frac{1}{m} = 328{,}016$$

The perturbations have been computed by ENCKE'S method of special perturbations on the basis of the elements, published in *Lick Observatory Bulletin* 179. They are for heliocentric rectangular *ecliptical* coordinates. They are given in units of the eighth decimal place:

PERTURBATIONS DUE TO THE ACTION OF *Venus*.

1910 Gr.M.T.	ξ	η	ζ
Mar. 23.0	0	0	0
Mar. 31.0	− 5	− 3	0
Apr. 8.0	− 19	− 11	0
16.0	− 44	− 27	− 1
24.0	− 78	− 49	− 5
26.0	− 88	− 56	− 7
28.0	−100	− 65	− 10
Apr. 30.0	−114	− 77	− 15
May 2.00	−131	− 95	− 25
2.25	−133	− 98	− 27
2.50	−135	− 101	− 29
2.75	−137	− 101	− 31
3.00	−.139	− 107	− 34
3.25	−141	− 110	− 36
3.50	−143	− 114	− 39
3.75	−145	− 118	− 42
4.00	−146	− 121	− 45
6.0	−156	− 154	− 71
8.0	−160	− 191	− 99
10.0	−162	− 229	−128
12.0	−161	− 270	−156
14.0	−160	− 313	−185
22.0	−154	− 503	−292
May 30.0	−157	− 718	−394
June 7.0	−172	− 951	−491
15.0	−199	−1193	−585
June 23.0	−235	−1439	−678
July 1.0	−277	−1685	−770

PERTURBATIONS DUE TO THE ACTION OF THE EARTH-MOON.

1910 Gr.M.T.	ξ	η	ζ
Mar. 23.0	0	0	0
Mar. 31.0	− 4	0	0
Apr. 8.0	− 16	− 2	0
16.0	− 36	− 4	− 2
Apr. 24.0	− 66	- 4	− 5
May 2.0	−103	− 3	− 10
4.0	−112	− 3	− 12
6.0	−123	− 4	− 13
8.0	−134	− 5	− 15
10.0	−146	− 7	− 16
12.0	−160	− 9	− 18
14.0	−177	− 14	− 20
16.0	−198	− 20	− 22
18.00	−225	− 32	− 25
18.25	−229	− 34	− 25
18.50	−233	− 36	− 26
18.75	−237	− 38	− 26
19.00	−241	− 41	− 26
19.25	−246	− 44	− 27
19.50	−250	− 47	− 27
19.75	−255	− 50	− 27
20.00	−260	− 53	− 28
20.25	−264	− 57	− 28
20.50	269	− 61	− 28
20.75	−274	− 65	− 29
21.00	−279	− 70	− 29
21.25	−284	− 75	− 29
21.50	−289	− 80	− 29
21.75	−294	− 85	− 30
22.00	−298	− 90	− 30
24.0	−335	− 140	− 30
26.0	−368	− 198	− 29
28.0	−398	− 259	− 28
May 30.0	−428	− 324	− 26
June 7.0	−541	− 604	− 17
15.0	−662	− 905	− 9
June 23.0	−796	−1220	− 4
July 1.0	−945	−1544	− 2

Berkeley Astronomical Department, 1910 *June* 15.

NOTE ON THE PREDICTIONS REGARDING THE TRANSIT OF HALLEY'S COMET, 1910 MAY 18,

By A. O. LEUSCHNER.

Computations relating to the transit of HALLEY'S Comet, 1910 May 18, were undertaken by the Berkeley Astronomical Department at the request of the Comet Committee of the Astronomical and Astrophysical Society of America.

The results were telegraphed to Harvard College Observatory on May 17 and are given in *Harvard College Observatory Astronomical Bulletin*, No. 407. In a second telegram which was distributed in *Harvard College Astronomical Bulletin*, No. 409, additional predictions were made regarding the passage of the Earth through the comet's tail. All of the calculations regarding the predictions referred to were carried out by Professor CRAWFORD and Mr. MEYER.

The purpose of this note is briefly to set forth the manner in which these predictions were derived and to record them in a more complete and revised form. This seems desirable in connection with the interpretation of any phenomena that may have been observed during the transit.

As a first step the elements, given by COWELL and CROMMELLIN in the Nov., 1909, number of the *Monthly Notices*, were corrected on the basis of three positions, the dates of which were: 1909 Sept. 17, Dec. 16, and 1910 Feb. 28. The corrected elements are published in *Lick Observatory Bulletin*, 179.

It was found that the perturbations due to the action of *Mars* at its nearest approach to the comet during January, 1910, were ineffective. On the basis of the corrected elements, the perturbations due to the action of *Venus* and the Earth, during March, April, and May, were computed with great accuracy. These are published by Professor CRAWFORD and Mr. MEYER in another part of this number.

By arrangement with Director CAMPBELL of the Lick Observatory, Dr. AITKEN secured a position of the comet on May 15.99, Gr. M.T. This was represented by the elements and perturbations referred to as follows, $O-C$:

$$\partial\alpha \cos\delta = -8' \; 28'' \quad ; \quad \partial\delta = -0' \; 33''.$$

In order to represent the motion of the comet as closely as possible during the time of transit, these residuals were made the basis for a correction of the date of perihelion and of the perihelion distance with the following results:

$$\partial T = +0.00137 \text{ M.S.D.} \quad ; \quad \partial q = +0.0003466.$$

The phenomena relating to the transit were then derived graphically on the basis of the elements published in *Lick Observatory Bulletin*, 179, after the foregoing corrections had been applied, and of the perturbations published in this number.

These same corrected elements and perturbations represent AITKEN'S observation of May 20.66, Gr. M.T., as follows, $O-C$:

$$\partial\alpha = -2^s.89 \quad ; \quad \partial\delta = 0''.$$

The graphical determination of the phenomena of the transit have since been revised numerically by Professor CRAWFORD and Mr. MEYER and differ but slightly from the results originally announced. The revised results are given below. The numbers in the column $\partial\Delta\alpha$ of the ephemeris represent the empirical corrections to the predicted values of $\Delta\alpha$ of the preceding column and are derived from the forgoing correction to the right-ascension of the comet on May 20.66, on the assumption that $\partial\alpha$ varied proportionally from 0^s on May 15.99, Gr M.T., to $-2^s.89$ on May 20.66, Gr. M.T. By applying the correction $\partial\Delta\alpha$ to the predicted $\Delta\alpha$, the apparent motion of the comet with reference to the Sun is accurately represented on the basis of AITKEN'S observations.

EPHEMERIS. (Comet – ⊙).

		′ ″		′ ″
May	18.375	−15 27.91	−1.48	−8 56.9
"	18.500	− 9 5.96	−1.56	−3 15.0
"	18.625	− 2 32.41	−1.64	+1 37.8
"	18.750	+ 4 11.25	−1.71	+5 35.9
"	18.875	+11 4.55	−1.78	+8 34.4

PHENOMENA OF APPARENT TRANSIT.

			Gr.M.T.	h	m	s
Geocentric	Ingress		1910 May 18	15	38	48
	Egress			16	37	38
	Middle of Transit			16	8	13
	Position Angle	Ingress	279°.4			
		Egress	75.7			

The comet passed 3′ 15″ north of the Sun's centre at the time of nearest approach.

Corresponding to the correction $\partial\Delta\alpha$ the predicted times of the phenomena of apparent transit require a uniform correction of $+49^s$. Therefore the middle of geocentric transit, for instance, occurred at $16^h \; 9^m \; 2^s$ Gr. M.T.

Aside from the empirical corrections derived from AITKEN'S observation of May 20.66, Gr. M.T., the difference between the foregoing data and those announced telegraphically is accounted for by the fact that the data here given are strictly for *apparent* transit.

The supplementary predictions regarding the passage of the Earth through the comet's tail contained in the second telegram (*H.C.O. Astron. Bull.*, No. 409) were based on the Mount Hamilton observations of the tail on the morning of May 19 (cf. Director CAMPBELL's telegram, *H.C.O. Astron. Bull.*, No. 408). These observations consisted in pointings on the tail, and were transmitted to the Students' Observatory by telephone. On the assumption, based on previous determinations, that the length of the tail at the time of the Mount Hamilton observations was 20 million miles, the angle at the head of the comet between the radius vector and the line drawn from the head to the point of the tail through which the Earth would pass was found by computation to be approximately 15°. The words: "Tail lags 15° at comet" of my telegram of May 19 (*H.C.O. Astr. Bull.*, No. 409) refer to this angle.

On the assumption of the same amount of lag at the time of the Earth's passage across the tail it was found by computation that this passage would be retarded roughly $20^h\ 40^m$ and that the Earth would pass $\frac{1}{20}$ of an astronomical unit below the axis of the tail. Unfortunately, in the telegram, the word "reported" was transmitted instead of "retarded," and the fraction "$\frac{1}{2}$" instead of "$\frac{1}{20}$".

It may be added that the diameter of the visible tail at the distance from the head at which the Earth passed the comet was less than 1.000.000 miles, so that the Earth probably did not encounter any of the cometary tail-matter which was observed on the morning of May 19.

The foregoing comments on the passage of the Earth across the tail are merely intended to correct any misinterpretation of the second telegram.

The final interpretation of the phenomena observed after the transit of the head of the comet across the Sun must be based on photographic and visual observations of the tail for a considerable interval before and after May 18.

Berkeley Astronomical Department,
University of California, 1910 *July* 13.

OBSERVATIONS OF MINOR PLANETS,

MADE AT VASSAR COLLEGE OBSERVATORY,

BY MARTHA A. RENNER AND PSYCHE REBECCA SUTTON.

Gr. M.T. 1909	*	Comp.	Δα	Δδ	App. α	App. δ	log pΔ		Red. to App. Pl.	
					(79) *Eurynome.*					
h m s			m s	′ ″	h m s	° ′ ″				″
Oct. 19 13 52 3.01	1	, 5	....	− 7 13.8	....	+15 23 20.5	.....	0.6849	.....	+14.6[1]
19 14 8 57.77	1	10 , *	− 26.39	....	2 59 12.66	....	9.5914*n*	....	+2.75	[1]
25 13 1 30.41	2	15 , 10	− 48.38	+ 44.1	2 55 5.94	+14 41 26.0	9.6278*n*	0.7031	+2.83	+15.2[2]
26 13 56 16.08	2	10 , 10	−1 34.79	− 6 57.7	2 54 19.60	+14 33 44.0	9.5646*n*	0.6701	+2.85	+15.3[2]
Nov. 1 13 52 35.29	3	10 , 10*	+ 29.52	− 2 41.3	2 49 28.81	+13 48 31.6	9.5244*n*	0.6642	+2.91	+15.7[1]
5 13 31 9.56	4	10 , 10	+ 50.72	− 2 10.4	2 46 6.55	+13 18 12.1	9.5275*n*	0.6700	+2.95	+16.1[2]
9 13 35 18.78	5	10 , 10	−1 5.65	+ 8 25.1	2 42 44.66	+12 48 10.5	9.4824*n*	0.6651	+2.97	+16.1[2]
					(8) *Flora.*					
Nov. 12 13 17 41.95	6	10 , 10	−1 9.70	− 1 14.8	3 43 57.27	+ 8 59 9.9	9.5828*n*	0.7199	+3.01	+13.5[2]
15 14 9 40.47	7	12 , 10	+1 3.08	− 2 43.2	3 40 47.44	+ 8 56 34.0	9.4767*n*	0.7007	+3.05	+13.6[1]
18 13 27 1.80	8	10 , 10	− 26.79	+10 13.1	3 37 39.09	+ 8 55 42.0	9.5284*n*	0.7084	+3.08	+13.7[2]
Dec. 4 13 24 42.45	9	10 , 10*	+ 1.38	− 7 32.8	3 22 18.34	+ 9 17 44.3	9.3505*n*	0.6859	+3.18	+13.9[2]
5 12 41 57.55	9	10 , 10	− 43.84	− 4 43.8	3 21 33.08	+ 9 20 33.2	9.4260*n*	0.6914	+3.18	+13.8[2]
6 12 58 52.53	10	10 , 10	+ 27.07	+ 1 17.7	3 20 47.66	+ 9 23 50.4	9.4003*n*	0.6885	+3.18	+13.9[2]
8 13 27 15.85	11	15 , 10	− 31.50	+ 1 11.4	3 19 21.84	+ 9 30 43.0	9.2728*n*	0.6794	+3.18	+13.7[2]
9 12 56 19.19	11	10 , 10	−1 10.91	+ 1 46.2	3 18 42.39	+ 9 34 17.8	9.3671*n*	0.6843	+3.18	+13.7[2]

Mean Places of Comparison-Stars for the beginning of the Year.

*	α	δ	Authority	*	α	δ	Authority
	h m s	° ′ ″			h m s	° ′ ″	
1	2 59 36.68	+15 30 15.0	Berlin A. A.G. 820	7	3 39 41.65	+ 8 58 58.0	Leipzig II. A.G. 1374
2	2 55 51.91	+14 40 21.7	Leipzig I. A.G. 896	8	3 38 3.18	+ 8 45 9.5	" " " 1365
3	2 18 56.72	+13 50 52.5	" " " 857	9	3 22 14.02	+ 9 24 58.0	" " " 1271
4	2 15 13.22	+13 20 1.7	" " " 830	10	3 20 17.67	+ 9 32 13.7	" " " 1262
5	2 43 17.65	+12 39 24.6	" " " 822	11	3 19 50.36	+ 9 29 12.9	" " " 1256
6	3 45 4.39	+ 5 59 55.3	" II. " 1409				

* Δα measured directly. [1] M. A. RENNER, Observer. [2] P. R. SUTTON, Observer.

MICROMETER OBSERVATIONS OF COMET *a* 1910,

MADE WITH THE 40-INCH TELESCOPE,

BY E. E. BARNARD.

1910 Central S.T.	✳	Comp.	$\Delta\alpha$	$\Delta\delta$	App. α	App. δ	Red. to App. Pl.	
h m s			m s	′ ″	h m s	° ′ ″	s	″
Apr. 12 16 2 51	1	4 , 6	+0 9.39	+0 51.3	22 39 38.80	+21 37 23.0	−1.13	−14.2
June 7 14 6 55	2	6 , 10	+0 2.71	−0 43.4	22 21 57.62	+31 9 58.8	+0.53	−11.3
12 13 22 39	3	5 , . .	+0 20.40	. . . . .	22 16 35.90	. . . .	+0.76	. . . . .
12 13 40 59	3	. . 9	. . . .	−0 12.2	. . . .	+31 47 4.6	. . . . .	−10.4

Mean Places of Comparison Stars for 1910.0.

✳	α	δ	Authority
	h m s	° ′ ″	
1	22 39 30.54	+21 36 45.9	9-10 mag. comp. with Berlin A.G.C. 8720.
2	22 21 54.38	+31 10 53.5	10 mag. comp. with Leiden A.G.C. 9489.
3	22 16 14.74	+31 47 27.2	Leiden A.G.C. 9430.

Star 1 — Berlin 8720 $\Delta\alpha$ +1ᵐ 47ˢ.75 (14tr) $\Delta\delta$ − 1′ 3″.5 (6)
Star 2 — Leiden 9489 $\Delta\alpha$ −1 37.68 (10tr) $\Delta\delta$ −1 53.5 (3)

MEASURED $\Delta\alpha$.

1910	″	
April 12	+130.9	(4)
June 7	+ 34.8	(6)
12	+260.2	(5)

Yerkes Observatory, 1910 *July* 11.

NOTES ON THE COMET.

1910 April 12. Faint; feebly condensed; 13th to 14th magnitude; rather large; no nucleus or elongation.

June 7. There is a slightly brighter portion 5″ diameter. The whole is perhaps 15″ diameter and the brightest part 16th mag.

June 12. Very faint. It diffuses over perhaps ½′ or more. There is a more condensed portion 5″ diameter and 16th magnitude.

COMET *b* 1910 (METCALF).

The *Astronomical Bulletin*, No. 420, of the Harvard College Observatory, contains the announcement that an orbit of the Comet, discovered by METCALF at Taunton, August 8, has been computed by Professor KOBOLD, from observations of August 11, 13 and 15, with the following result:

$$T = 1910 \text{ Aug. } 29.98 \text{ G.M.T.}$$

$$\omega = 42^\circ 12'$$
$$\Omega = 290\ 19$$
$$i = 121\ 26$$
$$q = 1.943$$

EPHEMERIS FOR GREENWICH MIDNIGHT.

1910	R.A.	Decl.	Light
	h m s	° ′	
Aug. 21	15 50 39	+ 16 3	0.77
25	45 24	+ 16 19	
29	41 1	+ 16 32	
Sept. 2	37 27	+ 16 44	0.60

OBSERVATIONS OF METCALF'S COMET, *b* 1910,

MADE WITH THE 26-INCH EQUATORIAL AT THE U.S. NAVAL OBSERVATORY,

[Communicated by Commodore T. E. DE WITT VEEDER, U. S. N. Superintendent.]

1910 Wash.M.T.	✳	Comp.	$\Delta\alpha$	$\Delta\delta$	App. α	App. δ	log $p\Delta$		Red. to App. Pl.	
h m s			m s	′ ″	h m s	° ′ ″			s	″
Aug. 10 12 4 47	1	30 , 6	−1 0.71	+2 33.1	16 10 29.33	+14 56 40.3	9.664	0.692	+1.43	+2.4
Aug. 18 9 29 4	2	25 , 5	−1 12.90	+1 0.7	15 55 3.67	+15 49 12.1	9.562	0.612	+1.25	+2.9

Mean Places of the Comparison-Stars for the Beginning of the Year.

✳	α	δ	Authority	✳	α	δ	Authority
	h m s	° ′ ″			h m s	° ′ ″	
1	16 11 28.61	+14 54 4.8	½ { A.G. Berlin A, 5818 } ½ { +A.G. Leipzig I, 5661 }	2	15 56 15.32	+15 48 8.5	A.G. Berlin A,.5725

The comet was observed on Aug. 10 by H. E. BURTON, and on Aug. 18 by J. B. EPPES.

ORION VARIABLE STARS,

By KEIVIN BURNS.

In the course of measuring eight plates for proper motions in the region of the Great Nebula in *Orion* the following variable stars were observed. The first column contains the number assigned by Bond in his work on the Nebula, published in Vol. 5, *H.C.O. Annals*. With one exception the discovery of the variables and suspected variables by Leavitt is announced in *H.C.O. Circular* 78, reprinted in *Aph.J.*, 19.289, and *A.N.*, 165.215. Star 663 is announced in *H.C.O. Circular* 86, reprinted in *A.N.*, 166.315. Star 801 is announced by Bond as variable but it is in a nebulous region and somewhat difficult to observe visually. It does not occur in the second catalogue of variable stars. It is certainly variable, no trace showing on three excellent plates, which show distinctly stars fainter than 801 is on five other plates. The maximum of this star and minimum of 506 depend on only one plate each. All other values of maximum and minimum in this table are means from two plates which give nearly the same values. In general the plates giving accordant results are separated by several months or several years. Stars 573 and 581 are involved in nebulosity and consequently the measures are inaccurate. These stars are close together and relative magnitudes show that at least one must be variable. 685, or θ_2, sometimes appear no brighter than 708, though usually over a magnitude brighter than this star. Stars 510 and 545 have equal intensity on all plates observed.

Bond No.	R.A.1900	Decl. 1900	Previous Observer	Minnesota		
				Max.	Min.	
	h m s	° ′		M	M	
Known Variables.						
435	5 29 46	−5 26.8	Leavitt	12.4	13.1	
663	30 25	24.9	Leavitt	12.6	>13.6	
709	32	29.6	Leavitt	11.8	12.6	
759	41	25.4	Leavitt	12.6	13.7	
784	5 30 47	−5 32.1	Leavitt	11.1	11.9	
Suspected Variables.						
524	5 30 6	−5 27.0	Leavitt	12.6	12.9	
558	11	29.4	Leavitt	11.4	12.0	Probably variable.
801	5 30 51	−5 32.0	Bond	12.9	13.9	Certainly variable, maximum one plate only.
New Variables.						
467	5 29 53	−5 38.3	. . .	8.0	8.7	
510	30 2	35.6	....	12.6	13.3	Same intensityas 545 on all plates observed.
545	9	34.0	....	12.6	13.3	
615	21	19.0	....	13.2	13.8	
741	37	29.2	....	8.7	9.3	
832	5 30 58	−5 27.6	....	12.6	13.7	
New Suspected Variables.						
506	5 30 1	−5 27.2	....	11.4	12.0	Minimum one plate only.
573	16	30.3	....	12.0	12.6	
581	16	30.0	....	12.5	13.0	
685	28	28.9	....	6.0	8.0	
708	5 30 32	5 29.0	....	7.4	8.1	

University of Minnesota; 1910 *July* 12.

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THE

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ON TWO IRREGULARLY PERIODIC VARIABLES: 6794 *R LYRAE*, 7754 *W CYGNI*,

By PAUL S. YENDELL.

The discovery, published from the Allegheny Observatory in January, 1909, of the true character of the light-changes of the variable star *u Herculis*, directed my attention to the class of so-called irregular variables, among which it had hitherto been ranked. An examination of my own observations of that star, of which the results have been published in this *Journal*, No. 610, p. 85, completely confirmed the spectroscopic discovery.

Reasoning from this, it seemed to me that an examination of my observations of some other stars of this class might very possibly lead to further discoveries of similar character. A cursory inspection of several of the series rather tended to confirm this impression. The pressure of other work interfering, it was not until February of the current year that I began the investigation, selecting as the first subject the star *R Lyrae*, of which my observations extend more or less continuously from October, 1888, until the present time.

R Lyrae.

The variability of this star was discovered by BAXENDELL in 1856. It is FLAMSTEED'S 13 *Lyrae*, and 107 of SCHOENFELD'S *Second Catalogue*, in which it is assigned a period of $46^{d}.0$ and a light-range from $4^{M}.3$ to $4^{M}.6$. It is 6794 of CHANDLER'S *Third Catalogue*, which gives a period of $46^{d}.4$, with a light-range of from $4^{M}.0$ to $4^{M}.7$. HARTWIG'S List for 1910 dismisses it with the remark "Amplitude *gering*," assigning a range from $4^{M}.0$ to $4^{M}.5$. It is quite red in color, being, according to CHANDLER'S observations, 4 of his scale of redness, and according to my own 1.6.

The comparison-stars, magnitudes from the *Potsdam Photometric General Catalogue*, and the light-scale used by me, are

		M	Lt.
ζ	*Lyrae*	4.52	13.3
η	*Lyrae*	4.68	11.8
a =	F16 *Lyrae*	5.32	5.0

The average light-range according to my observations is from $4^{M}.4$ to $5^{M}.1$.

Assembling my observations for the years 1888-1889, about two hundred in number, I tried a number of experimental mean light-curves, using as many different trial periods, all nearly commensurate with a day.

After numerous trials, a mean curve formed upon the period $0^{d}.979$ was found to satisfy very fairly the observations from which the curve was formed, but not those of the current season, which, though indicating an entirely similar curve, fall some four-tenths of a day late.

PLASSMANN'S observations for the same two years, on comparison with the same elements, show a similar curve to that formed from my own.

A curve formed by the use of the elements

$$\text{Max. 1888 October 29.194 Gr.M.T.} + 0^{d}.97955\ E$$

was found to satisfy the early observations, and also, within the limits of a reasonable error, those of the current season; but those of some of the intervening years are not quite satisfied by them.

It appears, however, that the main point, that the star varies regularly in a short period, is established as far as the means at my disposal enable me to do so; and while the results thus far obtained can by no means be regarded as definitive, that they warrant the publication of my conclusions, namely, that the star *R Lyrae* varies regularly between the magnitudes $4^{M}.4$ and $5^{M}.1$, in a period of approximately $0^{d}.97955$, the duration of increase and decrease being sensibly equal.

W Cygni.

The variability of this star was discovered in 1885 by GORE, and confirmed by SAWYER. It is 7754 of CHANDLER'S *Third Catalogue*, which assigns a period of 131.5 days and a light-range from $5^{M}.0$–$6^{M}.3$ to $6^{M}.1$–$6^{M}.7$. HARTWIG calls it "*wenig regelmässig*," and gives a range from $5^{M}.6$ to $6^{M}.7$. From my own observations and those of CHANDLER, SAWYER and GORE, I deduced in 1892 a period of 130.8 days with considerable irregularities. See this *Journal*, Vol. XII, p. 89. It is quite red, being 4.1 and 5 of CHANDLER'S color-scale by his observations and mine respectively.

The success of my investigation of the case of *R Lyrae* encouraged me to examine my series of *W Cygni*, which extends from 1891 to 1906, and numbers about three hundred. These observations appeared to me to show indications that the real character of the star's variation would be found to be that of a short-period star.

With the experience gained in the examination of the case of *R Lyrae*, which made it possible to dispense with much tedious tentative work, it was a comparatively easy matter to arrive at satisfactory results with *W Cygni*.

A period of $0^d.9924$ was found to satisfy the observations of the past years. On June 30.392 and .417 and July 11.375 of the present season I observed the star near the minimum light, the observed light being found to depart from the computed phase by $+0^d.022$, $+0^d.047$ and $+0^d.087$ respectively, the Epoch numbers being from 6988 to 6999.

From this it would appear that the elements and light-curve found are near approximations to the actual facts. The elements are:

Max. 1891 July 5.172 Gr.M.T. + $0^d.9924$ E

The readings from the mean light-curve found by comparison with the above elements are as follows: the column T gives the time from the maximum; the magnitudes are on the scale of the *Potsdam Photometric General Catalogue*.

	T	m	T	m
	−0.4974	6.49	+0.025	5.54
	.450	6.45	.050	5.58
	.400	6.40	.100	5.70
	.350	6.25	.200	5.95
	.200	6.05	.300	6.19
	.100	5.77	.400	6.41
	.050	5.60	.450	6.48
	−0.025	5.54	+0.495	6.49
Max.	0.000	5.52		

The comparison-stars used are as follows:

	m	Lt.
e = 75 *Cygni*	5.20	22.5
h = *g Cygni*	5.44	19.4
c = BD +44°3889	6.40	14.4
a = BD +45°3637	6.24	12.0
E = BD +43°3975	7.04	10.8
b = BD +44°3843	6.94	5.1
f = BD +45°3584	6.20	5.0

It is of interest to note the identical character of the light-curves of these two stars, as indicated by the results of the above examinations of the observations at hand; they are practically the same in type as that of *ζ Geminorum*, the increase and decrease being in all three cases sensibly equal. It is also interesting to note the similarity of color in the two stars, both being of very decided redness.

Dorchester, Mass., 1910 *July* 30.

TAIL OF HALLEY'S COMET,

By MARY W. WHITNEY.

The following observation was made at the Vassar College Observatory on the morning of May 19. The Moon set about 2.30 A.M., and from this time until dawn a shaft of light was seen in the east extending from a bright region on the northeast horizon through *Pegasus* toward the Milky Way. The boundaries of this streak could be traced with considerable distinctness and were laid down immediately on SCHURIG'S Atlas. The upper boundary passed through *η Androm.* *χ*, *ρ*, *α*, *ε Pegasi*, and *θ Aquilae*. The lower passed through 72,42 *Piscium*, 58, 55, *ρ*, *θ Pegasi*, *l Aquilae* and ended just under *θ Aquilae*. Thus it will be seen that it was widest at *γ Pegasi* where its width was about 8 degrees and tapered toward the farther end where it was only 4 degrees in width. The sky was quite dark on each side of the shaft of light but entirely clear. Below the lower dark streak the sky was bright, and the bright region lay along the ecliptic and was probably the zodiacal light. The most striking feature of the phenomenon was that the beam of light tapered away from the Sun instead of growing broader.

The observation was made by C. E. FURNESS and H. M. SWARTZ.

Vassar College Observatory, June 22.

THE SKY FOR THE NIGHT OF MAY 18–19,

By JOHN T. HEDRICK.

The only thing unusual seen here on the night of May 18-19 was the color of the sky to an altitude of about 20°. This was a darkish red in the north, but lighter in the east over the city of Washington. The color was obvious, though not striking. It was first noticed about half-past ten, but may have been present before. It disappeared between one o'clock and a quarter past. No flickering was seen.

From half-past ten to one o'clock, three of the students here kept a watch over the northern sky but saw no meteors. Nor did any attract attention in the 12-inch telescope with a field of 50′ diameter and the eye at the telescope about half the time between nine o'clock and one.

There were thin clouds in the southwest. The rest of the sky was bright from the Moon but seemed to be clear.

Georgetown College Observatory.

OBSERVATIONS OF HALLEY'S COMET,

MADE WITH THE 16-INCH REFRACTOR OF GOODSELL OBSERVATORY OF CARLETON COLLEGE,

By H. C. WILSON and R. E. WILSON.

1910 Local M.T.		*	Comp.	Δα	Δδ	App. α	App. δ	log pΔ		Red. to App. Pl.	
	h m s			m s	′ ″	h m s	° ′ ″			s	″
Feb. 26	7 21 59	1*	12 , 6	+0 36.05	− 6 5.8	0 35 53.29	+ 7 53 28.4	9.614	0.760	−1.50	− 7.8
Mar. 4	7 12 7	2*	9 , 6	−0 45.43	+ 2 36.7	0 31 10.24	+ 7 55 22.4	....	....	.....	..
4	7 12 7	3*	3 , 2	−2 31.13	− 3 0.5	0 31 10.21	+ 7 55 23.1	9.623	0.775	−1.54	− 8.2
8	7 9 2	4*	9 , 6	+0 5.48	− 3 12.2	....	....	9.626	0.779	.....	..
Apr. 19	16 24 46	5*	9 , 6	+0 52.88	+ 3 25.4	23 51 53.10	+ 7 46 40.2	9.624*n*	0.777	−1.14	− 8.9
May 3	16 6 14	6*	12 , 6	+0 3.52	+ 8 23.3	23 57 50.28	+ 8 35 35.3	9.596*n*	0.758	−0.89	− 7.5
4	15 48 30	7*	9 , 6	−0 19.90	+ 0 28.0	0 0 5.70	+ 8 47 7.1	9.622*n*	0.771	−0.88	− 7.3
20	8 28 49	8*	3	....	− 4 51.1		+18 35 11.2	..	0.793	.....	+ 3.4
20	8 34 16	8*	9	+0 50.42	......	5 40 43.76	....	9.638	....	−1.05	.
23	9 0 47	9*	13 , 6	+0 19.94	+ 2 20.6	....	....	9.615	0.755	.....	.
25	10 5 2	10*	10 , 6	−0 3.63	− 1 26.4	8 53 8.85	+ 7 27 28.0	9.621	0.775	−0.21	+ 0.9
27	8 12 33	11*	9 , 6	+0 34.86	+ 0 17.0	9 20 17.58	+ 5 9 23.0	9.494	0.758	−0.08	− 0.2
27	8 31 46	11†	9 , 6	+0 43.71	− 0 28.9	9 20 26.43	+ 5 8 37.1	9.524	0.761	....	.
28	9 16 32	12*	10 . 6	+0 6.74	− 4 24.8	9 30 50.61	+ 4 14 8.9	9.570	0.771	−0.03	− 0.6
30	9 2 30	13†	9 . 7	−1 37.22	+ 1 29.4	9 45 56.86	+ 2 53 52.7	9.546	0.775	+0.04	− 1.3
31	9 36 47	14†	9 , 7	+0 18.65	− 5 58.3	9 51 55.69	+ 2 21 43.7	9.580	0.779	+0.05	− 1.4
June 1	8 56 49	16†	9 , 6	−0 25.12	− 0 3.0	9 56 48.99	+ 1 55 34.5	9.535	0.778	+0.07	− 1.6
2	9 12 14	18*	9 , 6	−0 49.32	− 4 14.6	10 3 13.98	+ 1 31 45.8	9.551	0.781	+0.08	− 1.8
6	10 18 24	19*	9 , 6	−0 40.95	+ 6 16.4	10 14 21.49	+ 0 20 46.3	9.609	0.787	+0.10	− 2.3
13	9 22 4	20*	9 , 6	−1 7.71	− 1 28.1	....	....	....	....	.....	.
13	9 22 4	21*	9 , 6	−1 15.85	− 1 25.0	10 28 7.79	− 0 54 44.4	9.580	0.790	+0.14	− 2.5
15	9 40 13	22†	9 , 6	−0 49.97	+ 4 53.1	10 31 3.04	− 1 10 55.0	9.597	0.784	+0.11	− 2.6
17	9 9 30	23†	9 , 6	+0 3.60	+ 4 52.0	10 33 39.33	− 1 25 35.1	9.578	0.792	+0.09	− 2.6
21	9 21 40	24†	9 , 6	−0 17.12	− 1 36.1	10 38 18.93	− 1 51 42.8	9.597	0.792	+0.09	− 2.6

* H. C. Wilson. † R. E. Wilson.

Mean Places of the Comparison Stars for 1910.0.

*	α	δ	Authority	*	α	δ	Authority
	h m s	° ′ ″			h m s	° ′ ″	
1	0 35 18.74	+ 7 59 42.0	DM. +7°92,Tou.Ph.Cat.	13	9 47 34.04	+ 2 52 24.6	A.G. Albany 3893
2	0 31 57.21	+ 7 52 53.9	10^M. Mic. comp. with 3	14	9 51 36.99	+ 2 27 43.4	10^M. Micr. cp. with 15
3	0 33 42.88	+ 7 58 31.8	A.G.Leipzig II	15	9 52 47.75	+ 2 32 7.8	A.G. Albany 3916
4	....	....	DM. + 7°69	16	9 57 14.04	+ 1 55 39.1	10^M. Micr. cp. with 17
5	23 51 1.36	+ 7 43 23.7	Schj. 9920	17	9 58 15.24	+ 1 55 14.1	A.G. Albany 3943
6	23 57 47.65	+ 8 27 19.4	A.G. Leipzig II 11858	18	10 4 3.22	+ 1 36 2.2	A.G. Albany 3967
7	0 0 26.48	+ 8 46 46.4	A.G. Leipzig II 11870	19	10 15 2.34	+ 0 14 32.2	A.G. Nicolajew 3035
8	5 39 54.39	+18 39 58.9	A.G. Berlin A 1683	20	10 29 15.4	− 0 53 13.	9^M.5
9	....	.. .	DM. + 11° 1766	21	10 29 23.50	− 0 53 16.1	Göttingen 2668
10	8 53 12.68	+ 7 28 53.5	Küstner (Bonn) 3965	22	10 31 52.90	− 1 15 45.5	A.G. Nicolajew 3090
11	9 19 42.80	+ 5 9 6.2	A.G. Leipzig II 5103	23	10 33 35.64	− 1 30 24.5	A.G. Nicolajew 3095
12	9 30 43.90	+ 4 18 34.3	A.G. Albany 3819	24	10 38 35.96	− 1 50 4.1	Munich I 5669

VELOCITIES OF PARTICLES IN THE TAIL OF HALLEY'S COMET,

By PERCIVAL LOWELL.

The photographs taken here of HALLEY'S Comet have furnished experimental evidence of the mode of genesis of the tail. Measurement of certain irregularities in that appendage has shown its particles to be moving under the action of a repulsive force directed from the Sun.

Although the comparatively orderly behavior of HALLEY'S Comet has made measurable caudal irregularity rare, it has been possible on occasion to detect lapses from monotonous uniformity sufficiently pronounced to be capable of identification on successive plates. On May 23, 1910, two such plates were taken by Mr. LAMPLAND, Dr. SLIPHER and Mr. E. C. SLIPHER with a Brashear doublet of five inches aperture, one exposed from $9^h\ 23^m$ to $9^h\ 58^m$; the other from 10^h to $10^h\ 53^m$. The irregularities visible in the tail on these plates are of two kinds, thickenings or thinnings of the tail in places and abrupt changes of direction in it; knots and notches. As these are of necessity long drawn out, great accuracy is not possible and therefore the resulting determinations for the velocities cannot be considered exact. The interesting thing about them is their pointing unmistakably to solar repulsion.

On the plates the respective distances of the several knots and notches from the nucleus, measured in half millimetres for greater accuracy, proved to be as follows:

HALLEY'S COMET. 1910 May 23.

DISTANCE OF KNOTS IN TAIL FROM NUCLEUS.

	Plate I	Plate II	Diff. in ½ mm
Knot 1	40.3	43.3	3.0
Knot 2	92.2	95.8	3.6
Knot 3	134.3	138.3	4.0
Knot 4	182.6	188.8	6.2

We must now apply to these measures the correction for refraction. The lengths of the star-trails on the two plates at the head and at the points occupied by the knots were:

	Plate I	Plate II	
Head	5.9	8.6	½mm
Knot 1	5.9	9.0	
Knot 2	5.9	9.5	
Knot 3	5.9	9.9	
Knot 4	5.9	10.5	

The first plate witnesses to a practically uniform refraction throughout. The plate was taken at a considerable altitude above the horizon. The time of its exposure was 35 minutes. That of the second was 53 minutes. Consequently under similar conditions the second's star-trails should have been 8.85 ½ mm long. The table shows this to be nearly the case for those about the head and the star trails to have increased from there outward. Now the effect from guiding on the head is to keep the star-trails normal in the neighborhood of that head, but to lengthen them out elsewhere by the amount of the differential refraction. The half-difference in the star-trails at any two points must, therefore, be added to the outer to get its true place.

Thus we find the following table:

HALLEY'S COMET.

DIFFERENTIAL DISTANCE OF KNOTS IN TAIL FROM NUCLEUS.

	Uncor.	Corrected for Refrac.	Red. to Arc ′
Knot 1	3.0	3.2	6.2
Knot 2	3.6	4.1	7.9
Knot 3	4.0	4.7	9.1
Knot 4	6.2	7.2	13.9

For the date of the photographs, May 23.75 G.M.T., we have, calling r = the Comet's distance from the Sun

$\triangle$ = the Comet's distance from the Earth

R = the Earth's distance from the Sun

a = the semi-major axis of the Comet's orbit

$\log r = 9.9662$

$\log \triangle = 9.3303$

$\log R = 0.00552 \qquad \log a = 1.25395$

which from

$$V^2 = \mu\left(\frac{2}{r} - \frac{1}{a}\right)$$

gives 26.53 miles a second for the speed of the comet's nucleus.

From the data also we deduce

$R = 1.013$

$r = 0.925$

$\triangle = 0.214$

$s = 1.076 \qquad s-b = 0.151 \quad s-c = 0.862$

and from the relation

$$\sin \frac{1}{2} A = \sqrt{\frac{(s-b)\quad(s-c)}{bc}} = 54^\circ.2$$

whence the tail proceeding from the Sun was inclined to the line of sight 71°.8 as a mean.

We have for the distances in degrees from the head of the several knots examined, allowing for the differing inclination:

	Apparent,	Corr'd for Refrac. °	′	Cor. for Inclin. °	′
Knot 1	43.5	1	24	1	28
Knot 2	96.3	3	6	3	12
Knot 3	139.0	4	28	4	36
Knot 4	189.8	6	6	6	15

and for the differentiated distances corrected for inclination:

	′
Knot 1	6.5
Knot 2	8.2
Knot 3	9.4
Knot 4	14.2

giving for the speed of the particles composing the knots:

Knot 1	13.6 miles a second
Knot 2	17.2 miles a second
Knot 3	19.7 miles a second
Knot 4	29.7 miles a second

Here we are confronted by an increase in velocity away from the head as the particle gets farther away, an excess of speed which betrays the action of a repulsive force. Owing to the diffuse character of the knots, more detailed information is not possible.

The peculiar significance of these measures of the accelerated velocity of the tail away from the head in HALLEY'S Comet appears upon taking into account the spectroscopic evidence. Simultaneously with the photographs, slitless spectrograms of the tail were secured on almost every night for a period of seven weeks by Dr. Slipher. Those of the 23d of May show that the tail was then composed of carbon monoxide, hydrocarbons and a continuous spectrum which suggested to me that molecules themselves were the repelled particles. According to Dr. Slipher's estimate the light was about equally divided between the carbon monoxide and the continuous spectrum, the hydrocarbons yielding but little.

On the face of it, therefore, the probability that the displacement of the knots was due to molecules is greater than that it was occasioned by particles. Pursuant to this suspicion of mine Dr. Slipher points out that the spectrum of Morehouse's Comet was almost wholly emissive, both head and tail. Now the knots in that comet were very marked. We may therefore infer that molecules do certainly compose knots in comets' tails. Furthermore these knots have shown the same progressive increase of motion from the head with increased distance from it. They have been so measured by Quenisset and Baldet in France, by Dr. Miller at Swarthmore, Pa., and by me, each determination having been made without knowledge of the others. From which it appears that in Halley's Comet the solid particles rather obscured the knots than otherwise.

Here, then, we have new insight into the mode of formation of the tail. That the energy due to the light-waves could drive matter away from the light source, we were shown theoretically by Clerk Maxwell long ago. That any form of electric waves due to dynamo currents traversing the ether, when absorbed, must produce a repulsion, was demonstrated experimentally by Elihu Thomson in 1886 and the same effect was shown for light-waves independently by Lebedeff in 1900 and by Nichols and Hull in 1901. In 1892 Lebedeff tried to explain on this principle the tails of comets, regarding them as gaseous. In 1900 Arrhenius evolved his general theory of comets, corona, etc., on the same principle. In consequence, however, of a paper by Schwarzschild, he subsequently modified his views, and in his *Worlds in the Making* wrote as follows: "It results, therefore, that molecules, which have far smaller dimensions than those mentioned (0.3 of the wave-length), will not be repelled by the radiation pressure, and that therefore Maxwell's law does not hold for gases."

From the phenomena of Halley's Comet observed at Flagstaff, it would seem that molecules are driven away from the Sun by the impact of its light and that their speed of repulsion has been measured in the visible tail.

OBSERVATIONS OF THE COMPANION OF *SIRIUS* WITH THE 40-INCH REFRACTOR,

By E. E. BARNARD.

The following observations of the companion of *Sirius* are a continuation of the measures printed in *A.N.*, 4345, and *A.J.*, 541.

		°	″	
1909.915	Nov. 30	90.31	9.07	Faint but measures good.
1910.022	Jan. 8	90.10	9.04	Faint from poor seeing.
.025	9	89.29	9.11	Seeing very fine.
.159	Feb. 27	90.15	8.79	Not very well seen.
.164	Mar. 1	88.64	9.13	Faint. Seeing poor.
.175	5	88.46	9.10	Companion bright.
.183	8	88.22	9.15	Fairly well seen but jumping.
.203	15	87.07	9.17	Fairly well seen. Seeing = 2.
1910.106		89.09	9.07	

Yerkes Observatory, 1910 *July* 12.

AUGUST METEORS,

By EDWIN F. SAWYER.

Meteors were looked for on the evenings of August 9, 11, 12 and 13. Very clear skies prevailed except on the 10th which was overcast. The watch occupied nearly five hours, between the hours of 10 and 11.30. The hourly rate for one observer, covering about one-sixth of the visible sky, and with centre of observation in *Perseus*, was about 15 on the 9th and 11th, 8 on the 12th, and 6 on the 13th. Very few were noted other than *Perseids*. From several good tracks mapped on the 9th, with foreshortened paths near the centre of radiation, including one nearly stationary, the radiant point was found to lie at R.A. 38½°; Decl. + 55½°. The meteors were generally bright, 1st or 2d magnitude, with streaks lasting one or two seconds.

Since the bright showers of 1871 and '72, the yearly displays have been rather meager.

North Weymouth, Mass.

OBSERVATIONS OF THE SATELLITE OF *NEPTUNE*, 1909–1910,

By E. E. BARNARD.

The following observations of the Satellite of *Neptune* are a continuation of those in *A.J.*, 596, and *A.N.*, 4340. They have been made, with one or two exceptions, with a magnifying power of 700 diameters.

	C.S.Time	P.A.	Dist.	Comp.	Remarks
1909	h m s	°	″		
Sept. 24	16 28 40	104.72	....	7	Satellite $13^{M}.5$
	16 33 17	.....	16.60	4	
	16 35 57	.....	16.69	4	Faint in fogging sky.
Sept. 28	15 46 6	234.20	....	6	Faint from
	15 50 34	.....	12.09	4	moonlight and
	15 53 23	.....	11.80	4	misty sky.
Oct. 3	15 47 51	102.12	...	5	Very faint. Fog
	15 52 6	....	9.70	4	on object
	15 55 36	....	9.45	4	glass.
Oct. 26	14 59 28	301.99	....	5	
	15 2 20	.....	15.69	4	Faint in dense
	15 5 10	.....	15.41	4	haze and bad seeing.
Nov. 14	14 18 39	239.43	....	6	
	14 22 21	.....	12.46	4	Very faint and
	14 25 16	....	12.77	4	difficult from bad seeing.
Nov. 30	13 23 9	318.40	....	7	
	13 32 0	.....	14.65	5	
	13 37 3	.....	14.13	5	Exceedingly fnt. in clouds.
Dec. 7	11 22 41	272.78	....	6	
	11 26 32	.....	16.09	4	Fairly bright.
	11 29 2	.....	16.27	4	Seeing v. bad.
Dec. 19	11 6 22	261.90	....	6	
	11 10 55	..	14.99	4	Very difficult in
	11 13 22	.....	14.50	4	v. bad seeing.
Dec. 28	11 34 48	69.49	....	5	Meas. uncertain.
	11 39 37	...	15.15	4	Excess. diffic. fr.
	11 42 44	..	14.54	4	moonli't, haze and bad seeing
1910					
Jan. 6	11 24 17	240.29	..	6	
	11 29 43	...	12.62	5	Very difficult.
	11 33 6	.....	13.28	6	fr. bad seeing.
Jan. 8	11 11 20	104.47	...	6	
	11 17 3	..	17.16	5	Seeing very bad.
	11 20 9	...	16.98	5	Very high wind.
Jan. 9	12 58 3	51.34	..	5	Satellite 13^{M}
	13 1 29	.	12.81	4	Seeing fine but
	13 3 47		12.24	4	sky thick and satellite faint.
Feb. 1	10 4 31	85.01		6	
	10 10 9	..	16.33	5	Seeing very bad.
	10 13 53	.	16.14	5	Very high wind.
Feb. 6	10 22 17	121.12		6	
	10 26 38		15.95	4	Satellite faint.
	10 29 8		15.58	4	? if object obs. is the satellite.
Feb. 6	10 33 28	258.38	...	5	Object is 2^{M} br.
	10 36 51	.....	18.09	4	than the satel.
	10 39 38	.....	17.84	4	(?). Meas. dif. Wind. p. see'g.
Feb. 8	12 34 56	1.28		6	
	12 40 42	.	11.03	5	
	12 51 59	....	11.64	5	Very ft. in clouds
Feb. 12	9 20 26	298.09	...	5	Satellite $14^{M}.5$
	9 25 12	...	14.68	4	Fnt. See'g v. bad.
	9 28 51	..	14.21	4	Very high wind ? if satellite.
Feb. 12	9 34 17	117.62	.	5	Object = 14^{M}
	9 38 29	...	16.21	4	? if a star.
	9 41 32	...	16.24	4	Difficult from bad seeing.
Feb. 27	9 52 57	285.06	....	5	
	9 56 5	....	16.50	4	Faint in clouds.
	9 58 30	.....	16.51	4	
Mar. 1	6 41 34	161.54	....	6	
	6 47 36	.....	11.45	4	Thr. breaks in
	6 50 13	.....	11.27	4	clouds. Fairly well seen.
Mar. 5	11 30 50	275.02	....	6	
	11 38 2	....	16.33	5	Faint in clouds.
	11 42 40	....	15.79	5	
Mar. 8	8 46 37	98.79	....	5	
	8 50 38	.....	16.70	4	Well seen. Obs.
	8 53 4	.....	16.70	4	good. F'nt star 2^{M} less than sat. abt. same distance prec.
Mar. 12	10 0 34	217.36	...	5	
	10 3 37	.....	11.96	4	? if the satellite.
	10 7 4	.....	12.03	4	
Mar. 13	10 13 30	135.82	....	5	
	10 18 23	.....	14.12	4	Seeing very poor
	10 21 19	....	14.35	5	but satel. easy. V. high wind.
Mar. 15	7 3 7	44.60	...	5	Fairly well seen.
	7 6 50	....	11.92	5	
	7 9 42	....	12.08	5	
Mar. 22	8 16 9	310.23	.	5	Very faint. See-
	8 19 31	...	14.31	4	ing very bad.
	8 22 3	....	11.32	4	
April 2	10 7 56	0.51	.	8	Very difficult
	10 16 12	.	10.73	5	and uncertain
	10 22 28		10.72	5	in clouds.
April 12	7 33 42	113.14		5	Faint. Exces-
	7 37 48	..	16.26	5	sively bad
	7 11 28	...	16.47	4	seeing.

Yerkes Observatory, 1910 *July* 11.

THE PASSING OF THE EARTH AND THE TAIL OF HALLEY'S COMET,

By C. D. PERRINE.

In all of the observations and discussions which I have seen to date from the northern hemisphere of the passing of the Earth and HALLEY'S Comet, I have seen no mention of the great southern branch of the tail which was visible in southern latitudes, and through which the Earth probably passed.

The mornings of May 14, 15, 16 (astronomical reckoning) were cloudy in Cordoba. Observations were secured, however, on the mornings of May 17, 18, 20 and 21.

Following are my notes made at the time.

1910, *May* 17 (*Wednesday morning*).

Sky clear except for moisture. Night was cloudy from soon after dark until midnight or later. At $15^h\ 45^m \pm 5^m$ Cordoba mean time, tail of comet was very conspicuous to the east, extending from the horizon to the Milky Way which was then on the meridian or a little west (at the point of intersection). Tail was from 3° to 5° in width at brightest part. No structure could be seen.

$16^h\ 30^m$ to $17^h\ 0^m$. Sky examined from roof of main building at intervals. Sky was pure and stars very sharp in all parts of sky except in region around comet's tail, especially to the south, where stars and sky appeared misty. This may be and was probably due, in part, to the zodiacal light, and, lower down near the horizon, to moisture in the air. There may have been some effect from the diffuse portions of the comet's tail.

The comet's tail was considerably brighter than the Magellanic Clouds.

Width of tail *decreased* away from the horizon, *i.e.* was widest near the horizon.

Fog on ground at 6 A.M.

May 18 (*Thursday morning*).

There are clearly two branches to the tail, extending from the horizon fully up to the Milky Way in *Aquila*. The northernmost of these branches is much the brighter, estimated at twice that of the southern branch. The outlines of the northern branch have been located on a map by means of the stars. From this it appears that this branch is about 7° or 8° wide, at its middle. It is narrower and fainter at its extremity near the Milky Way. It widens slowly and brightens considerably towards the horizon.

The southern branch is separated from the northern branch by about the width of the latter. Both branches are sensibly parallel. The southern branch is at least twice the width of the northern one (or about 15°). Both branches are sensibly straight.

θ *Aquilae* is near the axis of the N. branch.
ϵ *Pegasi* is near the N. border of the N. branch.
γ *Pegasi* is near the S. border of the N. branch.

The N. border of the (wide) southern branch passes very near to β *Aquarii*.

The S. border of the S. branch extends almost as far as β *Ceti*.

The middle of the N. branch is intrinsically about as bright as the Nebeculae.

The southern branch is estimated to be about half as bright.

The sky was overcast at $15^h\ 45^m$. Soon after a band appeared near the horizon in which the comet's tail was seen, and shortly after the sky cleared in the region of the comet. Clear from $16^h\ 0^m$ to $16^h\ 54^m$, when clouds came over.

May 19 (*Thursday evening*).

Cloudy. No chance.

May 19 (*Friday morning*).

Drizzling rain. Heavy clouds. No chance.

May 20 (*Friday evening*).

Clouds until ? Clear at $10^h\ 15^m$. No trace of any streamers at that time. Moon very bright. Think, however, that any streamers as bright as the brighter on Thursday morning would have been seen.

May 20 (*Saturday morning*).

$15^h\ 45^m$. Moon still up. Could see no trace of comet's streamers.

$16^h\ 20^m$. Moon has now set and faint streamers are to be seen to the east, similar to those of May 18 (Thursday morning), except: (A) They are both fainter, the northern one being relatively much the fainter. (B) Both are wider and more widely separated.

N. streamer is 10° wide.
S. streamer is 20° + wide.
Separation is 10° or 12°.

Both streamers are farther north than on May 18.
α *Pegasi* is on the southern border of the N. streamer.
θ *Aquilae* is not far from the axis of the N. streamer.
γ *Pegasi* is near the middle of the band separating the two streamers.

Venus is not far from the axis (a little to the N.) of the broad S. streamer.

Both streamers extend to the Milky Way but cannot be traced beyond it with certainty. The broad S. streamer passes a little to the N. of the zenith, say 5°, seems a little bright or in the zenith.

May 21 (Saturday evening).

Tail traced for 60° with naked eye. Sky good.

May 21 (Sunday morning).

$17^h\ 0^m$ to $17^h\ 10^m$. Moon setting and sky to N.E. sufficiently dark to show cometary band if it existed. Only zodiacal band through *Venus* is visible. This is almost as strong as yesterday morning. Sky good. Air cold and damp.

Photographs were secured on the mornings of May 17 and 18 (among others) with a small single lens which covered a field of about 60° with a light ratio of $1 : 1\frac{1}{3}$. The bright tail is well shown on two exposures on May 17. No certain trace exists on them of the southern tail. Only one exposure was secured on May 18. The bright N. tail is well shown on this as well as a portion of the broad southern band. Owing to the great angular aperture of this lens and to the size of dome and narrowness of slit the southern side of the field was cut off.

Of the reality of this wide southern branch there is not the slightest doubt. Although very much fainter than the bright northern branch, it was at once picked up on the morning of May 18. It was also easily and certainly recognized on May 20. Unfortunately this southern branch was almost coincident in position with the zodiacal light, and to this is probably to be attributed the fact that it appears not to have been seen by northern observers.

There appears to be little or no doubt that the brighter portion of the tail passed entirely to the north of the Earth. If the wide southern branch persisted, there is practically no doubt that the Earth passed through it about May 20 or 21, civil time. It should be observed here that the moonlight on the evenings of May 20 and following made it impossible to see any object as faint as the southern branch. It cannot be said, therefore, whether this branch persisted after May 20 (Saturday morning).

If the mistiness observed on Wednesday morning (May 17) was in reality due to cometary matter, then it may be possible that the Earth passed through a portion of the tail at about the time that the comet transited the Sun.

Cordoba, 1910 *July* 25.

ELEMENTS OF MINOR PLANET, J.G. 1909,

By JOSEPH B. REYNOLDS.

This planet was discovered by Joel H. Metcalf, Dec. 11, 1909, and was named by his permission "*Lehigh*." The elements computed from four photographic positions, taken on Dec. 11, 1909, Jan. 2, 1910, Jan. 16, 1910, and Feb. 1, 1910, follow:

Observed *minus* computed for 1st and 4th positions:

$$\triangle\beta = +6''.53 \qquad \triangle\beta''' = +5''.18$$

Epoch, 1910.0, G.M.T.

$$\begin{aligned} M &= 57^\circ\ 55'\ \ 7''.92 \\ \left.\begin{aligned} \pi &= 24\ \ 54\ \ 36.54 \\ \Omega &= 88\ \ 54\ \ 34.62 \\ i &= 13\ \ \ 1\ \ 36.53 \end{aligned}\right\} & \ \text{Ecliptic and Mean Equinox 1910.0} \\ \phi &= \ \ 7\ \ 16\ \ 10.83 \\ \log a &= .4790764 \\ \mu &= 678''.2534 \end{aligned}$$

$$m_0 = 12^M.8$$
$$g = \ 8^M.9$$

Opposition, Dec. 26, 1909

Lehigh University, 1910 *August*.

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DETERMINATIONS OF STELLAR PARALLAX,

[From Photographs Taken at the Cambridge Observatory (England) by ARTHUR R. HINKS and the Writer.]

By HENRY NORRIS RUSSELL.

The present communication contains the final results of the first series of observations for stellar parallax made at the *Cambridge Observatory*. The plans for the work* were prepared by Mr. A. R. Hinks, Chief Assistant at the Observatory, and the writer — who had been appointed a Research Assistant of the *Carnegie Institution* for the purpose of this investigation. Mr. Hinks and the writer are also jointly responsible for the photographic observations in nearly equal shares. The former contributes 43%. For the measurement and reduction of the plates, which was begun at Cambridge and completed at Princeton, and for the results and conclusions here detailed, the writer is alone responsible.

The determinations of photometric magnitude and spectrum were made at the *Harvard College Observatory*, the latter by Mrs. Fleming, and the former by Prof. E. C. Pickering, to whom the writer's most hearty thanks are due for this extremely important addition to the value of the work.

I. Methods of Observation and Reduction.

A detailed account of the methods employed in the present work, with the reasons for their adoption, is given in the paper by Mr. Hinks and the writer, already referred to. It may be summarized as follows:

The photographs were taken with the Sheepshanks Equatorial of the Cambridge Observatory† — a *coudé* telescope of the polar siderostat type, of 12 inches effective aperture and 19.3 feet focal length. The stability of this instrument, and the performance of its driving clock and electric control, were so satisfactory that no attempts were made to guide by hand.

The plates, coated on plate-glass, cover a field a little less than $1\frac{1}{2}^\circ$ square. Four exposures were usually made on each, separated by $\frac{1}{2}$ mm. in declination. With the standard exposure of five minutes, stars are shown to the eleventh (photographic) magnitude.

Separate plates were taken on each night, and developed at once — because, in an uncertain climate, photographs whose success depends on the securing of good images on the same plate at three different dates are very liable to be spoiled by the failure of one set, and also because the conditions of the work made it necessary that measurement should be begun as soon as possible.*

All plates were taken as nearly as possible on the meridian, to avoid the introduction of the very serious systematic errors,† depending on spectral type and magnitude, which may arise from atmospheric dispersion, and from instrumental causes.

In order to obtain measurable images of bright stars, along with the much fainter stars of comparison, the former were photographed through a color-screen, consisting of a small patch of gelatine, stained with a yellow dye (which diminished the photographic brightness of the light passing through it by about $5\frac{1}{2}$ magnitudes) on a plane-parallel glass plate, placed just in front of the sensitive plate.‡ This worked very satisfactorily for more than a year, until the gelatine patch, contracting, pulled off the surface of the glass. The observations of stars brighter than the fourth magnitude were thus interrupted, and the parallaxes of a number of them had to be determined from observations at two epochs, with the aid of their known proper motions. Data concerning the accuracy of this process will be given later.

It should be an easy matter to construct a color-screen free from this danger, *e.g.* one sealed in between two glass plates.

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* Hinks and Russell, *M.N.*, LXV., pp. 775–787.

† Described by Sir Robert Ball, *M.N.*, LIX., pp. 152–155.

* The alternative method (Kapteyn's) is also liable under some circumstances to systematic errors depending upon the magnitude. See Kostinsky. *Publ. de l'Obs. Cent. Nicolas, Série* II., Vol. XVII., part 2, pp. 69, 138. Tikhoff. *Poulkovo Mittheilungen*, No. 18, p. 101.

† Called hour-angle error by Kapteyn. *Pub. Ast. Lab. Groningen*, No. 1, p. 68.

‡ This device is due to the writer.

A standard Gautier astrographic réseau was impressed on all the plates before development, and the positions of the star-images referred to this. Since each star is in practically the same position, relative to the same réseau lines, on all the plates of a given field, errors of position of the lines will affect only the star-places, and not the differences of their coordinates on the various plates, from which the parallax is derived. They have consequently been neglected.

The errors of the measuring machines[*] used at Cambridge and Princeton were carefully investigated, and found to be less than the least reading of the instrument (0.0005 mm., corresponding to 0″.018).

From five to ten comparison-stars (usually eight), distributed as symmetrically as possible about the "parallax star," were measured on each plate. At first every image was measured in two positions of the plate (with the coordinates apparently increasing to the right and the left) to eliminate the well known personal error of bisection. Later it was found (at Mr. Hinks's suggestion) that if two of the four images of each star were measured in one position of the plate, and the other two in the other position, the personal error was satisfactorily eliminated. This saved half the work of measurement.

Only the x-coordinates (right-ascension) were measured, with rare exceptions, as the y's did not give the parallax with sufficient weight. The latter were measured roughly on one or two plates of each field, for use in the reductions. In these, a convenient plate, or the mean of two, was chosen as standard, and the others reduced to it by Turner's linear formulae, whose constants were determined from the measures of the comparison-stars by the short method proposed by Dyson.[†] If the comparison-stars are properly distributed, the results of this process, for the principal star, are practically identical with those of the more laborious least-squares method.[‡]

The residuals for the principal star were then discussed by least-squares in the usual way to find the parallax, and corrections to the assumed position and proper-motion.

The parallaxes and proper-motions of the comparison-stars (relative to the mean for each field) were also determined, by a shorter approximate process.[§]

II. Table of Observed Parallaxes.

The following table gives the results of observation for the fifty-two stars which were the principal objects of investigation. Those for ten stars have already been published,[*] but are included here for completeness. For three of these (Nos. 13, 18 and 19) the tabular parallaxes are derived from measures in both the x and y-coordinates.

The magnitudes and spectra are those determined at Harvard — the former by Professor Pickering with the meridian photometer, the latter by Mrs. Fleming — except for three stars whose spectral type (in the absence of other satisfactory data) was roughly estimated from the difference of their visual and photographic magnitudes.[†] The results are enclosed in parentheses in the table.

The proper-motions are taken from Boss's *Preliminary General Catalogue*, whenever possible, and the rest mainly from Bossert's *Catalogue of Proper-Motion Stars*. That of No. 39 is derived from comparison of the plates with *A. G. Lund*, using nine comparison-stars. The parallaxes of Nos. 1 to 44 are derived from least-square solutions, including corrections to the proper-motions. Those of Nos. 45 to 52 are derived from observations at two parallactic epochs with the aid of the catalogued proper-motions (see above). All are *relative* parallaxes with respect to comparison-stars of about the ninth magnitude.

The probable errors which immediately follow them are smoothed values resulting from an adjustment depending on the photographic magnitude, and for Nos. 45 to 52 include the estimated effect of the uncertainty of the proper-motion relative to the comparison-stars.

Those resulting directly from the least-square solutions, are given in a later column, headed "Observed p. e." In the writer's opinion, the former are decidedly to be preferred.

The intervening columns give the number of plates on which the work is based. Each usually contained four exposures, but contributed a single equation of condition. The next column contains the number of comparison-stars for each field.

There are twelve pairs of stars on the list which have common proper-motions, and are presumably physically connected — some of them being undoubtedly binary systems. In these cases the simple mean of the two observed parallaxes is adopted for both stars. The manner of computing the probable errors assigned to these means will be explained later.

The last two columns contain the absolute magnitudes of the stars (corresponding to the parallax 0″.100) and their cross-velocities (at right angles to the line of sight) in kilometers per second. In computing these the observed parallaxes have been increased by 0″.006, or in a few cases 0″.008, to allow for the parallax of the comparison-stars. When the observed parallax is less than its probable error, these data are not given. Many of those which are included are of course liable to a very large percentage of error.

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[*] For a full description of the former see Hinks, *M.N.*, LXI, pp. 444–458. The Princeton machine is simpler, but of the same type.

[†] *M.N.*, LV., p. 61; LVI., p. 118. See also Turner, *M.N.*, LIV., p. 189.

[‡] Plummer, *M.N.*, LXIV., p. 646.

[§] For an example see *M.N.*, LXV., p. 791.

[*] *M.N.*, LXV., pp. 787–800; LXVII., pp. 132–135.

[†] *Harvard Annals*, LXIX., No. V, p. 152.

Observed Parallaxes.

No.	Star	R.A. 1900	Decl. 1900	Mag.	Sp.	P.M.	Parallax	p. e.	Pl.	Cmp Star	Observed p. e.	Absolute Magnitude	Cross Vel'y Km/Sec
		h m	° ′			″	″	″			″		
1	β *Cassiopeiae*	0 3.8	+58 36	2.42	F_5	0.56	+0.082	±0.019	5	9	±0.009	2.1	31
2	Groombr. 34	0 12.7	+43 27	7.73	*Ma*	2.80	+0.250	±0.016	6	9	±0.011	9.8	51
3	26 *Andromedae*	0 13.3	+43 15	6.04	*A*	0.03	−0.026	±0.042	6	9	±0.041	. . .	. . .
4	η *Cassiopeiae*	0 43.0	+57 17	3.64	F_8	1.24	+0.187	±0.019	7	8	±0.021	5.1	30
5	ο *Ceti*	2 14.3	− 3 26	var.	*Md*	0.24	+0.136	±0.035	7	9	±0.035	2.5 to 10.4	8
6	ρ *Persei*	2 58.8	+38 27	var.	*Mb*	0.17	+0.083	±0.040	7	9	±0.040	3.1 to 3.9	9
7	β *Persei*	3 1.7	+40 34	var.	B_8	0.01	+0.007	±0.027	7	8	±0.025	. . .	. . .
8	Lal. 6888	3 40.2	+41 9	8.35	*G*	1.38	−0.029	±0.033	6	6	±0.033	. . .	. . .
9	Lal. 6889			8.89			+0.020	±0.034			±0.035	. . .	. . .
						Mean	−0.004	±0.030					
10	Lal. 7443	3 56.5	+35 2	8.34	G_2	2.20	−0.011	±0.014	6	8	±0.006	. . .	. . .
11	Groombr. 884	4 44.4	+45 41	6.83	*G*	0.68	+0.078	±0.019	6	8	±0.013	6.4	38
12	Groombr. 1646	10 21.9	+49 21	6.50	F_8	0.90	+0.049	±0.023	7	8	±0.021	5.2	77
13	Lal. 21185	10 57.9	+36 38	7.42	*K*	4.78	+0.344	±0.014	8	9	±0.013	10.1	65
14	Lal. 21258	11 0.5	+44 2	8.63	K_5	4.40	+0.163	±0.018	9	6	±0.015	9.8	124
15	83^1 *Leonis*	11 21.7	+ 3 33	6.36	*K*	0.74	+0.048	±0.034	7	5	±0.033	5.3	58
16	83^2 *Leonis*			7.51			+0.057	±0.033			±0.035	6.4	
						Mean	+0.052	±0.031					
17	Groombr. 1830	11 47.2	+38 26	6.46	*G*	7.04	+0.100	±0.029	8	7	±0.030	6.6	315
18	γ *Virginis*	12 36.6	− 0 54	3.65	*F*	0.56	+0.055	±0.032	8	6	±0.033	2.9	38
19				3.68			+0.070	±0.026			±0.026	2.9	
						Mean	+0.063	±0.026					
20	Berlin A 4999	13 40.2	+18 21	9.98	(G_5)	1.89	+0.105	±0.024	8	7	±0.020	10.2	81
21	Lal. 25372	13 40.7	+15 26	8.30	K_5	2.32	+0.221	±0.020	8	9	±0.019	10.1	48
22	Berlin B 5072	14 21.1	+24 6	9.40	*K*	1.38	+0.059	±0.036	7	7	±0.044	. . .	. . .
23	Berlin B 5073			9.64			−0.012	±0.027			±0.027	. . .	. . .
						Mean	+0.024	±0.029					
24	A.Oe. 14318	15 4.7	−15 59	9.09	*K*	3.75	+0.045	±0.022	6	7	±0.019	6.9	495
25	A.Oe. 14320	15 4.7	−15 54	8.86	G_5		+0.014	±0.023			±0.025	6.7	
						Mean	+0.030	±0.021					
26	Lal. 27742	15 8.3	+19 39	6.83	*G*	0.68	−0.039	±0.051	5	8	±0.058	. . .	. . .
27	Lal. 27743			7.63	*A?*		−0.077	±0.038			±0.036	. . .	. . .
						Mean	−0.058	±0.041					
28	W.B. 15h, 716	15 32.4	+40 10	7.78	*K*	0.47	+0.020	±0.013	8	8	±0.005	6.1	48
29	W.B. 15h, 720	15 32.5	+40 8	6.83	G_5		+0.059	±0.019			±0.014	5.2	
	(*O*Σ 298)					Mean	+0.040	±0.015					
30	W.B. 17h, 322	17 20.8	+ 2 14	7.82	*Ma*	1.36	+0.095	±0.016	11	7	±0.012	7.8	64
31	Pos. Med. 2164	18 41.7	+59 29	9.33	*Ma*	2.27	+0.291	±0.042	6	8	±0.038	11.7	35
32	(Σ 2398)			10.01			+0.306	±0.049			±0.052	12.4	
						Mean	+0.298	±0.041					
33	Lam. 18180	18 53.1	+ 5 48	9.14	(*G*)	1.26	+0.076	±0.065	6	8	±0.065	8.7	73
34	Groombr. 2789	19 9.5	+49 39	6.84	*K*	0.64	−0.011	±0.049	7	7	±0.034	. . .	. . .
35				6.62			+0.075	±0.063			±0.067	. . .	. . .
						Mean	+0.032	±0.050					
36	B.D. +30°3639	19 30.9	+30 18	9.85	*O*	. . . .	−0.018	±0.022	6	6	±0.022	. . .	. . .
37	61_1 *Cygni*	21 2.4	+38 15	5.57	K_5	5.27	+0.406	±0.024	11	10	±0.024	8.5	63
38	61_2 *Cygni*			6.28	K_5	5.15	+0.361	±0.021			±0.023	9.2	
						Mean	+0.384	±0.021					
39	B.D. +38°4362	21 5.2	+38 19	7.68	*K*	0.06	−0.035	±0.029	10	10	±0.029	. . .	. . .
40	Lal. 43492	22 12.3	+12 24	6.97	F_8	0.83	+0.021	±0.023	6	8	±0.015	. . .	. . .
41	A.G.H.-G 13170 (Krüger 60)	22 24.5	+57 12	9.43	(K_5)	0.95	+0.258	±0.019	8	9	±0.013	11.5	17
42	Lal. 45755	23 16.8	+43 33	7.56	F_8	0.68	+0.037	±0.021	7	8	±0.021	5.8	71
43	Lal. 46650	23 44.0	+ 1 52	9.09	K_5	1.40	+0.211	±0.023	6	10	±0.015	10.8	30
44	Lam. 32805	23 44.9	+ 2 19	8.28	*G*	0.44	−0.022	±0.033	6	10	±0.033	. . .	. . .

No.	Star	R.A. 1900	Decl. 1900	Mag.	Sp.	P.M.	Parallax	p. e.	Cmp Star.	Pl.	Observed p. e.	Absolute Magnitude	Cross Vel'y Km/Sec
		h m	° ′			″	″	″			″		
45	*η Geminorum*	6 8.8	+22 32	var.	*Ma*	0.07	+0.034	±0.025	5	3	±0.017	1.3 to 2.3	8
46	*α₁ Geminorum*	7 28.2	+32 6	2.85	*A*	0.20	+0.104	±0.036	6	9	±0.029	3.0	9
47	*α₂ Geminorum*			1.99	*A*		+0.102	±0.028			±0.011	2.2	
						Mean	+0.103	±0.029					
48	*γ Serpentis*	15 51.8	+15 59	3.86	F_8	1.33	−0.081	±0.024	4	8	±0.011		
49	*ζ Herculis*	16 37.6	+31 47	3.00	*G*	0.60	+0.101	±0.024	6	8	±0.021	3.2	27
50	*η Herculis*	16 39.5	+39 7	3.61	*K*	0.10	+0.014	±0.066	6	8	±0.065		
51	*μ Herculis A*	17 42.6	+27 47	3.48	G_5	0.82	+0.024	±0.028	7	8	±0.031	1.7	88
52	*μ Herculis BC*			9.68			+0.051	±0.049			±0.047	7.9	
						Mean	+0.038	±0.036					

III. Comparison with Kapteyn's Formulae.

Accordingly to Kapteyn's formula for the mean parallax of stars of given magnitude*, the mean parallax of all the comparison-stars is 0″.006. For the six which give evidence of proper-motion (averaging 0″.32) it is 0″.023. The mean parallax for the fields including one of these stars is therefore taken as 0″.008.

The observed parallaxes given in the table have been increased by these amounts before basing any calculations on them.

The resulting values compare as follows with those predicted by Kapteyn's formulae for the mean parallax of stars of given proper-motion and magnitude.† Grouping them first according to the magnitude of the predicted parallax, we find:

Limits of Computed Parallax	Mean Parallax Observed	Mean Parallax Computed	Number of Stars
″ ″	″	″	
>0.20	0.282	0.272	3
0.20 to 0.10	0.104	0.132	9
0.10 to 0.07	0.106	0.082	10
0.07 to 0.05	0.082	0.059	9
<0.05	0.015	0.021	9
All together	0.093	0.089	40‡

The general agreement is very good.

Taking means for groups of stars of similar magnitude proper-motion, or spectral type, the results are as follows:

Limits Mag.	No. of Stars	Mean Mag.	Mean P.M.	Mean Parallax Observed	Mean Parallax Formula	Ratio	Computed Ratio
			″	″	″		
4.0	12	3.2	0.49	0.070	0.073	1.0	1.1
5.6 to 7.0	9	6.4	1.83	0.079	0.110	0.7	0.8
7.1 to 8.0	6	7.5	1.75	0.126	0.095	1.3	1.3
8.1 to 9.0	6	8.5	2.41	0.079	0.109	0.7	0.9
9.0	7	9.4	1.31	0.113	0.063	2.3	1.3
P.M. ″			″	″	″		
Over 3.0	5	7.4	5.05	0.210	0.226	0.9	1.1
3.0 to 1.5	5	8.7	2.30	0.179	0.108	1.7	1.4
1.5 to 1.0	7	7.3	1.31	0.079	0.091	0.8	1.0
1.0 to 0.7	5	6.6	0.85	0.090	0.076	1.2	0.9
0.7 to 0.4	9	5.8	0.59	0.046	0.069	0.7	0.6
Under 0.4	9	4.6	0.10	0.010	0.023	1.7	1.4

Spectrum	No. of Stars	Mean Mag.	Mean P.M.	Mean Parallax Observed	Mean Parallax Formula	Ratio
			″	″	″	
O to F_5 (Type I)	6	4.3	0.23	0.042	0.045	0.9
F_8	5	5.7	1.00	0.050	0.097	0.5
G, G_2	8	7.1	1.78	0.039	0.103	0.4
G_5	4	7.3	1.73	0.059	0.096	0.6
K	6	6.9	1.28	0.078	0.074	1.1
K_5	5	8.2	2.87	0.254	0.140	1.8
M	6	5.9	1.15	0.156	0.072	2.2
Type II	34	6.7	1.62	0.102	0.096	1.1

The last column but one gives the ratio of the mean observed parallax for each group to the mean of the values predicted by Kapteyn's formula.

For the different spectral types these ratios vary in a strikingly systematic fashion. The first type stars (0 to F_5) are too few in number to permit of separation into subgroups; among the remaining stars, for which Kaptèyn's "second-type" formula was used, the ratio of the observed to the computed parallax increases rapidly and almost regularly with increasing redness from less than one-half for type *G* to more than double for type *M*. If the stars under discussion are separated according to magnitude (above and below 7.0) or proper-motion (greater or less than 1″.0) and similar ratios are taken (combining adjacent spectral classes to get enough stars), the results are as follows:

Spectrum	Average P.M.	Ratio	No. of Stars	Average P.M.	Ratio	No. of Stars
	″			″		
F_8 − G_2	2.41	0.4	6	0.68	0.6	7
G_5 − *K*	2.94	1.0	4	0.47	0.6	6
K_5 − *M*	2.82	1.7	7	0.35	3.3	4

	Average Mag.			Average Mag.		
F_8 − G_2	5.3	0.5	7	8.1	0.4	6
G_5 − *K*	5.1	0.7	5	8.7	1.0	5
K_5 − *M*	4.0	1.7	4	8.6	2.0	7

The phenomenon therefore appears to persist throughout a considerable range of magnitude and proper-motion.

For the average of all these stars together the observed and computed values are in close agreement, thus confirming KAPTEYN's formula for them as a whole. It is however evident that, with the more detailed spectroscopic data now available, the accuracy of the prediction of parallax can be considerably increased by taking these differences into account.

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* *Publ. of the Astronomical Laboratory at Groningen*, No. 8, p. 24.

† *Ibid*, No. 11, p. 18.

‡ For pairs of stars with common proper-motion, the mean of the parallaxes, and the other data for the brighter component, are taken, thus reducing the number of entries from 52 to 40.

For example, the ratios of the observed and computed parallaxes of the groups of stars of similar magnitude or proper-motion, given above, vary through a wide range in a very irregular fashion. If for each of these groups the mean of the ratios corresponding to the spectral types of the individual stars is taken, the values given in the last column, under the head "Computed Ratio" are obtained. It is clear that a large part of the irregularity of the observed ratios arises from the irregular distribution of stars of the different spectral types.

IV. RELATIVE BRIGHTNESS, ETC., OF STARS OF DIFFERENT SPECTRAL TYPES.

The individual values of absolute magnitude and velocity given in the table are much affected, and sometimes rendered quite illusory, by errors of observation. By taking the mean magnitude, proper motion, and parallax for groups of stars, this difficulty is diminished; but the values of the mean brightness, or velocity, computed in this way will be somewhat too small, owing to the neglect of the real differences in parallax among the stars of the group. They are, however, the best obtainable.

Grouping the stars according to spectral type, separating the brighter ones (mag. 2–4) and the fainter (mag. 6–10), and excluding three stars of proper-motion less than 0″.10, and the variable *Mira*, from the last group, for the sake of homogeneity, the results are as follows:

BRIGHT STARS.

Spectrum	No. of Stars	Mean Mag.	Observed P.M.	Observed Parallax	Abs. Mag.	Corresponding Luminosity*	Velocity Km/Sec
			″	″			
B_8 to F_5	4	2.6	0.33	0.070	1.8	31.	22
F_8 to M	7	3.7	0.62	0.060	2.6	14.	49
FAINTER STARS OF LARGE PROPER-MOTION.							
F_8	3	7.0	0.80	0.044	5.2	1.3	86
G, G_2	7	7.8	1.95	0.029	5.1	1.4	314
G_5	3	8.6	2.04	0.064	7.6	0.14	151
K	4	7.4	1.88	0.119	7.8	0.12	75
K_5	5	8.2	2.87	0.254	10.2	0.013	54
M	3	8.3	2.14	0.221	10.0	0.016	46

Little importance attaches to the values for the naked-eye stars, as these were selected for all sorts of reasons (binaries, variables, etc.).

The fainter stars, however, are apparently fairly homogeneous. The mean magnitudes and proper-motions are very similar for all the groups except the first (type F_8), and here the discrepancy is due to the mode of their selection.*

The marked progressive differences, in actual brightness and velocity, among these stars must have a real meaning. The association of the two is obviously due to the method of selection by magnitude and proper-motion combined. Intrinsically bright stars, to appear of this average magnitude, must be at considerable distances, and hence, to show the average proper-motion, must have very great velocities.

But either greater brightness or more rapid motion must be really characteristic of stars of type *G*, as compared with type *K*, and of these again as compared with type *M*.

There can be no hesitation between these two hypotheses. Recent investigations make it probable that a star's spectral type is very closely related to its surface temperature, and presumably to its surface brightness. In fact, the recent temperature determinations of SCHEINER and WILSING† indicate that a star of type *G* should be about two magnitudes brighter (visually) than one of equal diameter but of type *K*, and this again as much brighter than one of type *M*. This would account almost quantitatively for the observed data. On the other hand, there appears to be no reason why high temperature should go with great velocity in space; and spectroscopic evidence shows that the stars of no spectral type have as a whole greater velocities than the smallest in the part of the table which is under discussion.

It may therefore be regarded as probable that the differences in luminosity between stars of different spectral types, revealed in the table, are real and more or less typical, while those in velocity are results of this fact, combined with the mode of selection of the stars observed.

Confirmation of this is found in the table itself, for the stars of type F_8, which differ from the others in both apparent brightness and proper motion, appear to agree with those of the neighboring type *G* in real brightness, though differing greatly in velocity.

The remarkable deviations from KAPTEYN's formula, described above, may be attributed with some confidence to differences in the average intrinsic brightness of stars of the different spectral types.

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* In terms of the Sun, assuming its absolute magnitude to be 5.5 [after KAPTEYN].

* These stars were observed because their spectra were given as *A* in the DRAPER Catalogue. Parallaxes of such stars of considerable proper-motion were especially desired, so that the limit of proper-motion for admission was purposely lowered. Stars fainter than the average of those observed here are not included in the catalogue.

† *Potsdam Publications*, Vol. XIX., part 1, p. 67.

V. Masses of Binary Stars.

Among the stars observed for parallax are six binary systems, for which more or less satisfactory orbits have been computed. Their mean distances and periods, and the masses corresponding to the observed parallaxes, are as follows:

No.	Star	a	P yrs.	Mass	p	$\pi - p$
		″			″	″
4	η *Cassiopeiae*	8.51	233	1.6	0.168	+0.025
18,19	γ *Virginis*	3.90	182	5.3	0.091	−0.021
29	$O\Sigma$ 298	0.88	56	2.3	0.045	+0.001
46,47	α *Geminorum*	5.75	347	1.2	0.087	+0.022
49	ζ *Herculis*	1.38	34.5	1.8	0.098	+0.009
52	μ *Herculis* B.C.	1.45	43.5	(19.0)	0.088	−0.044

The average mass — excluding the last star, for which the errors of observation are unusually serious — is 2.4 times that of the Sun. The "hypothetical parallaxes," p, resulting from the assumption that each system has exactly this mass, are given in the preceding table, together with their difference from the observed values (corrected for the parallax of the comparison stars). The mean-square value of these differences is 0″.024, and that of the probable errors of the observed parallaxes is ±0″.025 The assumption that all the masses are equal therefore represents the observed parallaxes well within the errors of their determination, and it is clear that no importance attaches to the differences of the computed masses in the table.

There are also three slow binaries on the list, whose relative motion is distinctly curved, but covers too short an arc to permit the calculation of even a rough orbit.

In such cases the relative motion can be represented by the formulae:

$$s \cos (p - p_0) = x = a + b \ (t - t_0) - c \ (t - t_0)^2$$
$$s \sin (p - p_0) = y = a' + b' \ (t - t_0) \dots\dots\dots$$

s and p being the distance and position-angle at the time t, and terms involving the cube of the time being neglected.

Now by the law of gravitation $\frac{d^2 x}{dt^2} = -k \, \mathrm{M} \frac{x}{r^3}$ where r is the distance of the two stars, M the total mass and k a constant, which, if the astronomical unit, the year, and the Sun's mass are chosen as units, is equal to $(2\pi)^2$, or 39.48. If i is the angle which the radius vector makes with the line of sight, then at the epoch t_0, $r = a \operatorname{cosec} i_0$, and $\frac{d^2 x}{dt^2} = 2c$, whence $\mathrm{M} \sin^3 i_0 = \frac{a^2 c}{19.74}$. If a and c are expressed in seconds of arc, the cube of the parallax must be inserted in the denominator.

The second member of this equation is evidently a minimum value for the mass of the system. More cannot be said in an individual case until the elements of the orbit are known; but in the mean of a large number of cases the average value of $\sin^3 i_0$ will be $\frac{3\pi}{16}$ or 0.589 (exactly as in the analogous case for spectroscopic binaries.)

For the stars previously mentioned, the data and results are as follows:*

No.	Star	t_0	p_0	a	b	c	$\mathrm{M} \sin^3 i_0$
			°	″	″		
31, 32	Σ 2398	1870	144	15.96	+0.0624	0.00094	0.43
37, 38	61 *Cygni*	1857	106.4	17.77	+0.0913	0.00048	0.13
41	Krüger 60	1900	149	3.16	+0.0070	0.0128	0.35

The average value of $\mathrm{M} \sin^3 i_0$ is 0.30, and the most probable value of the average mass, one-half that of the Sun. These systems are therefore considerably less massive than the brighter ones previously mentioned — the uncertainty of the factor $\sin^3 i_0$ being insufficient to account for the discrepancy. Their intrinsic brightness is small in comparison with their mass, their light in terms of the Sun's being

	61 *Cygni*	Σ 2398	Krüger 60
Primary	0.063	0.0033	0.0031
Companion	0.033	0.0016	0.0009

The average mass of a component of one of these systems is one-fourth that of the Sun. Even with the improbably great density of 8 times that of the Sun (or 11 times that of water) its surface area would be $\frac{1}{16}$ of the Sun's. The actual surface brightness of the last two stars must therefore be very small, which is direct evidence of their low temperature. The spectral types of the brighter components are Ma and K_5. According to Scheiner and Wilsing, this indicates a surface brightness about $\frac{1}{40}$ that of the Sun. Unless the actual brightness is considerably lower than this, their density must be high.

VI. Distribution of the Different Spectral Types.

As the comparison-stars were chosen for their position and brightness on the plates, without knowledge of their spectra, the proportion of the different types among these may be of interest. The fields in which they lie may be divided into two groups — the first averaging 10° from the galactic equator, and the second 58°. The numbers and percentages of the different spectral types (counting G_5 as K, K_5 as M, etc.) in these two groups are as follows. Those among the stars of large proper-motion observed for parallax (see Section III) and among those of the latter whose parallax exceeds 0″.10 after allowance for the comparison-stars) are added for contrast. The few stars whose spectra were not observed are disregarded in computing the percentages.

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* Those for 61 *Cygni* are taken from Bergstrand (*Nova Acta Reg. Soc. Scient. Upsaliensis*, Serie IV., Vol. 1, No. 3), changing from 1902 to 1857; the others are computed by the writer.

Group		I	II	III	IV
		Comparison-Stars		Large	Large
		Galactic	Non-galactic	P.M.	Parallax
Mean Magnitude	Visual	9.38	8.93	7.89	8.21
	Photogr.	9.84	9.70	8.95	9.58
Number of Stars					
A		34	5	0	0
F		25	10	0	0
G		16	36	10	1
K		42	29	7	2
M		0	3	8	8
Not observed		4	5	0	0
Total		121	88	25	11
Percentages					
A		29	6	0	0
F		21	12	0	0
G		14	43	40	9
K		36	35	28	18
M		0	4	32	73

The very large percentage of red stars in the last two groups is explained by the fact already brought to light, that, among the fainter stars, faintness and redness go together. Stars invisible to the naked eye, and of large parallax, must of necessity be intrinsically very faint, and therefore most of them are red. For those which merely show a large proper-motion, this requirement is less rigorous, and more yellow stars (type *G*) are included. These stars, being brighter than the red ones, lie on the average farther away, and have greater average velocity. The limiting velocity which they must exceed, in order to appear of "large proper-motion," is in fact so great that only a small fraction of all the stars of this type exceed it. It is for this reason that the numbers of proper-motion stars of types *G* and *M* are nearly equal, though the parallaxes show that the former are being sought for in a region several hundred times greater in volume than the corresponding one for the latter.

The absence of faint stars of large proper-motion and spectra *B*, *A* and *F* is explainable on the hypothesis that these stars are of greater luminosity than those of type *G*, so that, to be invisible to the naked eye, they must be so remote that even the greatest velocities which actually occur among the stars do not give rise to an apparent proper-motion large enough to be included in our lists. The comparison-stars show the usual excess of type *A* in the Milky Way; but the actual percentages of this type, both in and out of the Galaxy, are surprisingly small. The ratio of these stars to those of types *F*, *G* and *K* together is 0.41 for the galactic fields, and only 0.07 for the others, while for all stars down to the magnitude $8^{M}.2$ (according to counts made on photographs taken at Harvard.* it is 2.10 in the Galaxy and 0.70 outside it.

So great a discrepancy is hard to explain. There seems to be no reason at all why any discrimination should have been made against type *A* in selecting stars when wholly without knowledge of their spectrum. The only data available for stars of comparable magnitude are based on a single Harvard plate,† giving a ratio of 2.9; but as this is of a rich region in the Milky Way, it may not be typical. On the other hand, the stars of the present work, though very widely distributed in the sky, are very few in number.

Further investigation of the relative proportions of the spectral types among stars of this magnitude is obviously very desirable. It is possible that among these faint stars the proportion of those of type *A* falls off, just as that of type *B* does among much brighter stars, with increasing magnitude.†

VII. Bearing on Stellar Evolution.

It is well known that a contracting gaseous mass must rise in temperature until it becomes so dense that the "gas laws" no longer hold approximately for its central portions. After this the dense nucleus offers an increasing resistance to further compression, the loss of heat by radiation increases relative to the gain by shrinkage, the temperature reaches a maximum, and then falls.

Before the maximum temperature is reached, the surface-brightness increases as the diameter diminishes, and it is not obvious whether the total light-emission rises or falls; but after the star begins to cool, diameter and temperature diminish together, and the decrease in luminosity must be rapid.

There can be little doubt that the faint stars of large proper-motion, discussed in the preceding paragraphs, are in the latter condition. The very rapid decrease of light with increasing redness, and the extremely small luminosity of the reddest stars, in spite of the fairly considerable masses of those which can be investigated, are distinctive marks of stars in a late stage of evolution, past their prime, and in some cases verging toward extinction.

If it is assumed that most of the stars which do not surpass the Sun in luminosity (and hence most of the fainter stars of large proper-motion) are in these later stages of evolution, the peculiarities of their distribution with respect to spectral type are immediately explained.

It should be especially noticed that, on the above hypothesis, there ought to be two kinds of red stars (*i.e.* of stars of low surface temperature) one in an early stage of evolution, of increasing temperature, small density, large diameter, and considerable total luminosity, and the other of decreasing temperature, great density, and very small luminosity. The reddest stars among the first-class would be in the earliest stages of evolution; in the second class, in the latest. Practically all the red stars visible to the naked eye must belong to the first class — as is shown by their small proper-motions, and in some cases by direct measurements of parallax (as for *Aldebaran* and *Antares*), which prove that their actual luminosity is much greater than the Sun's. To apply to them the considerations previously developed for red stars of the other type (*e.g.* the deviations from Kapteyn's formula) would be quite inappropriate.

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* *Harvard Annals*, LVI., No. 1, p. 21.

† *Loc. cit.*

VIII. Absence of Systematic Errors.

In addition to the stars especially chosen for observation the parallaxes of two hundred and forty-two comparison-stars were also determined from the measures. Their distribution with regard to magnitude shows that they are almost wholly due to the errors of observation. The numbers which actually lie between given limits compare with those predicted by the theory of errors (with probable error ±0″.0283) as follows:

Limits		+0″.12		+0″.09		+0″.06		+0″.03		0″.00		−0″.03		−0″.06		−0″.09		−0″.12	
Observed	1		4		16		41		61		64		36		14		2		3
Theory	1		3		15		39		63		63		39		15		3		1

Though these give us very little information about the parallax of individual stars of comparison, they furnish abundant material for the detection of any systematic errors which may influence the observed parallaxes. For example, if the stars are grouped according to magnitude and spectrum, the results are as follows:

Mean Magnitude	No. of Stars	Mean Parallax *without* regard to Sign	Mean Parallax *with* regard to Sign	Expectation
		″	″	″
7.22	25	0.037	+0.006	0.007
8.64	59	0.030	−0.001	0.004
9.51	106	0.034	−0.002	0.003
10.35	52	0.032	+0.003	0.004
Spectrum				
		″	″	″
A	40	0.031	−0.005	0.005
F	53	0.033	+0.008	0.005
G	65	0.033	+0.003	0.004
K, M	58	0.036	−0.002	0.005
Undetermined	26	0.033	−0.011	0.006

The quantities in the last column are obtained by dividing the average parallax, regardless of sign, by the square root of the number of stars in the group, and represent the values which the quantities in the preceding column might be expected to have, if the observed parallaxes were wholly due to accidental error.

It is clear that any systematic errors depending on the brightness or color of the stars must be exceedingly small.

If the stars are grouped according to their position in the field of the telescope, the results for the sixteen regions into which it was divided are as shown in the following diagrams:

No. of Stars				Mean Parallax regardless of Sign (Unit 0″.001)			
9	18	19	17	49	27	23	37
20	11	18	13	32	53	26	31
20	13	11	15	34	38	22	34
17	12	15	14	35	31	34	39

Mean Parallax with regard to Sign				Expectation			
+20	− 9	− 1	+14	16	6	5	9
−10	+15	− 2	− 1	7	16	6	9
+12	− 5	11	− 1	8	11	7	9
+13	− 9	−20	− 4	8	9	9	10

(Unit 0″.001).

The numerical mean of the observed quantities in the third diagram is 0″.0092, and of their expected values 0″.0090. Once more there is no trace of systematic error.

The foregoing tests, which include stars of all right-ascensions, would however fail to detect systematic errors — arising for example from seasonal change in the instrument — which are a function of the right-ascension. To search for these, the stars in each field were divided into two groups, differing in brightness, spectrum, or position, on the plate. The observed differences of the mean parallax of these groups, arranged in order of R. A., are as follows:

R.A.	Inner *minus* Outer	Exp.	Bright *minus* Faint	Exp.	White *minus* Red	Exp.
	Means with regard to Sign					
h	″	″	″	″	″	″
0	+0.002	0.008	−0.018	0.008	+0.008	0.009
4	+0.005	0.009	−0.001	0.009	−0.008	0.010
12	−0.003	0.009	+0.010	0.009	+0.017	0.010
16	−0.005	0.011	0.008	0.011	+0.014	0.014
20	+0.002	0.011	+0.016	0.011	−0.003	0.011
	Means without regard to Sign					
All	0.025	0.024	0.028	0.024	0.024	0.026

In this case also the numerical averages of the observed and the expected values are very nearly equal. Only in the case of groups of stars of different brightness does the observed difference of parallax sensibly exceed that which might be expected among groups of stars of equal number chosen wholly at random; and even in this case the differences for the individual fields appear to be distributed quite without system. 17 are positive and 14 negative, 15 are numerically greater and 16 less than the probable error computed from their numerical average; and, if they are arranged in order of R.A., there are 18 permanences and 13 changes of sign.

It may be concluded that *the parallaxes derived in the present work are free from sensible systematic error*, depending on the brightness or spectrum of the stars, their position in the field, or the season of the year at which observations are made.

The presence of a mirror in the optical train of the telescope seems to have had no ill effects whatever, although it was removed and silvered three times during the progress of the observations. This very satisfactory performance is perhaps to be accounted for by the facts that the mirror is flat, almost completely enclosed by the telescope body, protected from sudden changes of temperature, not exposed to heating by radiation, and always in the same position relative to the vertical during the observations of any given region.

The accuracy of the results depending upon observations at two parallactic epochs, and catalogued proper-motions, was tested by carrying out similar computations for the thirty-one other stars for which (as in the case of Nos. 45 to 52) at least two plates were available at each of the first two epochs.

The average excess of the approximate parallaxes so obtained above the definitive values derived from all the observations is +0″.008, regarding signs, and 0″.027, disregarding them. The approximate values depend on the average upon 4.7 plates and the definitive ones upon 2.9 additional plates as well. On the theory of errors,* the average difference between two such values should be to the average error of a definitive value inversely as the square roots of these numbers. The latter is 0″.033, which leads to the value 0″.026 for the former — leaving very little room for systematic error.

To avoid all danger of underestimating the probable errors of these parallaxes, they have been increased to the extent demanded by the assumption that the probable error of the proper-motions used in deriving them is ±0″.053, corresponding to the average value of the corrections derived for the five stars observed at three epochs with the color-screen. These "corrections" are largely due to errors of observation, and the real uncertainty of the relative proper-motion of the bright star and the comparison-stars is doubtless smaller; but it is best to be on the safe side.

Additional evidence of the minuteness of the systematic errors of the final parallaxes is afforded by comparison with the results of other observers — on whose independently prepared working lists many of the same stars appear.

The results, grouped according to the method of observation, are as follows:

Method	Average Excess above Present Work				No. of Comparisons
	without regard to Sign		with regard to Sign		
	″	″	″	″	
Heliometer	0.059	±0.042	+0.012	±0.010	18
Photography	0.048	±0.035	−0.026	±0.016	5
Micrometer	0.045	±0.033	−0.002	±0.015	5
Spectroscopic	0.018	±0.037	−0.012	±0.021	3
Transits	0.052	±0.035	+0.001	±0.012	9
All together	0.052	±0.038	±0.001	+0.006	40
Photography (subject to hour-angle error)	0.049	±0.042	+0.032	±0.015	8
Transits (FLINT)					
Uncorrected	0.144	±0.059	+0.048	±0.015	16
Corrected	0.109	. . . . . .	+0.028		

Those determinations in which systematic error has been detected by the observers themselves, or is liable to exist for well-known reasons, are listed separately at the bottom. The probable errors are computed from those derived by the observers, without any allowance for systematic error.

There is no evidence of constant differences between the results of different methods, except in the cases where systematic errors are known to exist (and here FLINT's corrections appear to have removed the greater part of the error).

If these cases are excluded, the probable error of one difference between the results of the present work and other observers, computed from the average discordance of these results, is ±0″.044. From the internal agreement of the observations of each series separately, it should be ±0″.038. The average effect of the combined systematic errors of the two therefore corresponds to a probable error of ±0″.022. For the heliometer observations it is ±0″.028, and for all the others ±0″.016.

If it is assumed that the sixteen determinations with the Yale heliometer, used in the above comparisons, have the systematic errors assigned to them by the observers*

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* Assuming that a given error has the same effect on the parallax, no matter on what plate it occurs — a good enough approximation for the purpose.

* *Yale Transactions*, Vol. II., part 1, p. 194.

(on the basis of ±0″.030 for the result of a single series) the average systematic error for an individual observer (with this exception) comes out ±0″.009 from the heliometer observations, and ±0″.011 from the others. It is not improbable that the systematic errors of the Yale observations have been over-estimated; but in any case it is clear that the average systematic error of the determinations of parallax in the present work must be of the order of magnitude of 0″.01.

IX. Sources of Accidental Error, and Conditions Favorable to Accuracy.

The error of a star-position, which is derived from the mean of the measures of several exposures on one plate, arises from several sources. These are

1 Error of *measurement* proper — giving rise to differences between successive measures of the same image and réseau-lines.

2. Errors peculiar to the individual *image* — which may be due to many causes — bad seeing, unequal sensitiveness of the plate, etc. These affect the real position of the center of the image or réseau-lines, but may vary in a random manner from one image to another.

3. Errors peculiar to the individual *plate*, which may arise from guiding error, systematic distortion of the film etc. These affect all the images of the same star on this plate to the same extent, but for different plates may be regarded as of random character.

4. Errors due to changes in the *instrumental conditions* from time to time. These cause the agreement of two plates, taken at a long interval, to be worse than that of two taken a few days apart, after allowance is made for the motion of the stars in the interval.

Only influences of this last type can give rise to systematic errors in the results of observation. From the evidence already obtained, it appears that they must be very small in the case of the present work.

5. In addition to these, there is, the *personal error of bisection*, differing systematically for stars and réseau-lines, and depending also on the appearance of the images. This has been eliminated from the mean results for each plate, by measuring half the images with the plate in one position, and the other half with the plate turned through 180°. Anything which is not so eliminated combines itself with one of the first three forms of error.

Let m, n, p, t, represent the probable errors arising from the sources (1), (2), (3) and (4) — which may reasonably be supposed independent. The probable error of a mean coordinate, derived from a plate with four exposures measured as described above, may be determined in several ways.

1. From the agreement of independent measures of the same plate. This gives $\frac{1}{2}m$.

2. From the agreement of the measures of the individual exposures on the plate. This gives $\frac{1}{2}\sqrt{m^2+n^2}$.

3. From the agreement of different plates taken within a few days. This gives $\frac{1}{2}\sqrt{m^2+n^2+4p^2}$.

4. From the observed parallaxes of the comparison-stars (which are almost wholly due to errors of observation) and the least-square solutions for the parallax stars. This gives $\frac{1}{2}\sqrt{m^2+n^2+4p^2+4t^2}$, and is the true measure of the accuracy of the observations.

In this way the following values of these errors have been found for the average results of the present work:

		Probable Error *mm.* etc.		″
Measurement-error	(m)	±0.0010	or	±0.036
Image-error	(n)	±0.0019	or	±0.066
Plate-error	(p)	±0.0010	or	±0.034
Instrumental change-error	(t)	±0.0006	or	±0.022

The personal error of bisection, which is eliminated by reversing the plate, amounts on the average to 0.0024 mm. or 0″.085.

The average probable error of a mean star-coordinate, derived from plates with different numbers of exposures, is, according to the foregoing:

±0.0019 mm. or ±0″.067 for 2 exposures
±0.0016 mm. or ±0.055 for 4 exposures
±0.0015 mm. or ±0.051 for 6 exposures

Certain important consequences follow from these data, which may have a bearing upon photographic work generally, though the statements here made can only be *proved* in the case of the present work.

1. By far the larger part of the error of the results derived from any star-image is *inherent in the image itself*, and cannot be diminished by any refinement of measurement of its position. It is therefore desirable to spend as little time as possible upon the latter. In the present work, where the time spent in measurement has been reduced to the absolute minimum, it contributes only one-ninth of the whole error of the average plate.

2. Fully half of the error of the results derived from any plate is *inherent in the plate*, and cannot be diminished by multiplying exposures upon it (on the same night). Additional exposures, after four or six have been obtained, add very little to the weight of the result, and it does not pay to make or measure them. How far a second plate, taken immediately afterward on the same night, escapes these errors is uncertain. In such a case it is desirable to make a small change in the rate of the pendulum which controls the driving clock, so that the "guiding error"

may be different for the two plates. This was done in the few cases of the sort occurring in the present work.

3. There is reason to fear that when we have two stars of comparable magnitude within a few minutes of arc in the heavens (or a few millimeters on the plates), the effects of the instrumental error, t, and of the plate-error, p — or at least of the guiding error which forms the greater part of this — will be practically identical for the two stars, as will also be any influence of errors of measurement of the comparison-stars, so that the parallaxes derived for the two from the same plates will not really be independent determinations. Twelve such pairs appear in the list of the stars observed for parallax. In every case the two stars have a considerable common proper-motion, and it is therefore practically certain that their parallaxes are sensibly identical. The difference of the observed values will thus afford a measure of those errors of observation which are not common to the measures of the two stars.

The mean-square value of this difference for the twelve pairs is ±0″.043, to which corresponds the probable error ±0″.029 for the difference of the two observed parallaxes, and ±0″.021 for each singly, if their errors were independent. But the mean-square probable error of a determination of parallax, relative to the comparison-stars, for one of these same stars is ±0″.035. It follows that those errors of observation which differ for the two stars of the pair account on the average for only 36% of the whole, leaving 64% as the contribution of errors common to the two stars on the same plate.

This is of the order of magnitude which was to be expected, for the above data show that for plates with four images of a star, each measured with double the usual number of settings (as was the case for the parallax stars) the errors p and t account for 56% of the whole error of the measured coordinates of this star. The error of the correction, computed from the measures of the comparison stars, and necessary to reduce the measures to standard, increases the square of the error of the reduced coordinate by about 12%. Hence 61% of the latter is due to known sources of error certainly or presumably common to the two stars of a pair. It is therefore unnecessary to go farther for an explanation of the observed facts.

It follows that the mean of the observed parallaxes of such a pair of stars has by no means twice the weight of an individual determination. According to the data just obtained it is 1.22 times that of one of the components.

It would therefore appear at first sight that the photographic method is in this respect at some disadvantage. But it should be remembered that the measurement of the second component of a pair on the plates involves very little additional work. The same comparison-stars and plate-constants serve for both, and the whole increment of labor after the plates are taken (if there are seven or eight comparison-stars) is hardly over 10%; so that the mean parallax of a pair of stars (provided they are not too close) can be determined with slightly greater accuracy in proportion to the work expended on it, than that of an isolated star.

The average probable error of one plate for the forty-four parallax stars observed at three or more epochs is ±0″.048. This is less than the average value just found for all the stars on the plate — which is not surprising, since the parallax stars are favorably placed at the center of the plate, and were measured with special care. The results for different classes of stars are, however, of very different degrees of precision.

There are five pairs of stars* on the list, whose images on the plate lie much closer to one another, in the direction of measurement, than the ordinary separation of the successive exposures (17″.6). The mean-square probable error for these ten stars is ±0″.0596, while for the remaining thirty-four stars it is ±0″.0437.

It therefore appears that the presence of a comparison-star, of comparable magnitude, within about 10″ (or 0.03 mm. on the plate) seriously diminishes the accuracy of the measures. This might be expected, owing to mutual disturbance of the images, which under ordinary conditions are from three to five seconds of arc in diameter.

This difficulty is due to the duplicity of the stars, and not to the photographic method of observation. When the stars are close, and of comparable brightness, observations with the heliometer (and doubtless with other instruments as well) are diminished in accuracy in the same way, as was found by Gill in the case of *α Crucis*.†

It is clear that only the isolated stars offer a fair test of the accuracy of the photographs. Three of these, however (Nos. 3, 39 and 44), are at some distance from the center of the fields on which they appear, being observed because they happened to lie on plates taken primarily for some other star. The mean-square probable error for these is ±0″.059, and for the remaining thirty-one stars is ±0″.042. This is again what might be expected, for the accuracy of the measures, and also of the corrections necessary to reduce them to standard, diminishes toward the edge of the field.

For the stars observed under normal conditions the accuracy of observation varies considerably with the photographic magnitude — as is shown by the following values for groups of five or six stars.

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* Nos. 8–9, 15–16, 18–19, 31–32, 34–35.

† *Cape Annals*, Vol. VIII., part 2, p. 55 B.

	M	M	M	M	M	M
Photographic Magnitude	7.2	7.6	8.6	9.4	10.2	10.8
	m	m	m	m	m	m
Average Exposure	3.7	3.9	4.0	4.3	5.0	4.6
	″	″	″	″	″	″
Mean-Square p.e. of one plate	±0.048	0.035	0.029	0.035	0.051	0.047
Computed	±0.047	0.041	0.032	0.032	0.039	0.047

The values in the last line are computed from the formula $r^2 = 0.0010 + 0.0004\ (m-9)^2$ . . . (1). The agreement is close except in the next to the last column. Here the observed mean is raised by the very large p.e. for a single star (No. 33), arising from extreme discordance of a single under-exposed and very poor plate. The mean for the other stars is ±0″.042, in close agreement with the formula.

The probable errors for the close double stars are well represented by setting 0.0030 in place of 0.0010 in the above formula.

The observations of the stars photographed at two epochs only appear to be of comparable accuracy with the rest.

The deviations from the formula in the case of individual stars are probably largely due to the very small number of observations. But it does not seem certain that they are wholly so; and therefore the mean of the probable errors given by the formula and by direct observation has been adopted as definitive, except for a few stars* where the existence of unusually large errors of observation was suspected, and the observed values — in these cases greater than the others — were given the preference.

These results show the great importance of *correct exposure*. The range of brightness within which measures of the highest precision can be made on a given plate is decidedly limited, not exceeding two magnitudes. A departure of one magnitude on either side of the most favorable brightness decreases the weight of an observation to seven-tenths, and one of two magnitudes to less than one-third, of its maximum value.

Part of this error is due to the character of the images of bright or faint stars — the former being too large, and often too diffuse at the edge, for accurate measurement, and the latter too ill-defined, often without any definite center to set on. But it is probable that some of the other sources of error are also considerably increased — *e.g.* guiding error for bright stars, and that arising from unequal sensitiveness of the plate for faint ones.

Over- or under-exposure, sufficient to impair seriously the accuracy of the measures, can often be recognized on inspection of the star images. With longer series of plates, it would probably be advisable to reject, *a priori*, any on which the images of the parallax star were defective in this respect. In the present case, this would be too drastic; but such plates were given diminished weight.

It would have been well if the exposures for the faint stars had been longer. Those for the bright stars could not well have been much curtailed, owing to the necessity of getting good images of the comparison-stars; but a color-screen of small absorption (two or three magnitudes), would make it possible to get good images of both.

The mean-square value of the probable error given by formula (1) for stars within one magnitude of the most favorable brightness may well be taken as a measure of the average accuracy of observation attainable in the present research. This is readily found to be ±0″.0356, which corresponds to ±0.00101 mm. on the plates. It may fairly be claimed that this represents a high standard of accuracy.

X. Proper-Motions.

Determinations of the proper-motion in x (R.A.), of all the stars observed at three or more epochs are a by-product of the work — though the time-interval is of course too short to give any great accuracy. Of the two hundred and forty-two comparison-stars, only six appear to have proper-motions in this coordinate exceeding 0″.2 per annum, and none exceed 0″.4. The individual proper-motions of the remainder cannot be separated from the errors of observation. If these are grouped according to the interval covered by the observations, the average values of the observed parallax and proper-motion, without regard to sign, together with their mean weights, as found in the least-square solutions for the parallax stars, are as follows:

Grp.	No. of Stars	Average Parallax	Weight	Average P.M.	Weight	Expectation	Outstanding P.M.
		″		″		″	″
I	101	0.034	2.58	0.059	0.93	0.057	0.015
II	47	0.034	3.12	0.051	1.70	0.046	0.022
III	29	0.029	2.96	0.031	3.39	0.027	0.016
IV	59	0.032	3.57	0.022	10.52	0.019	0.012

The observed proper-motions decrease rapidly with increasing weight, showing that they are principally due to accidental error. If they were entirely due to this cause, the mean proper-motion and parallax for each group should be in the inverse ratio of the square roots of their weights. In this way the quantities in the column headed "Expectation" are derived from the observed mean parallaxes. These are uniformly smaller than the observed proper-motions. The most reasonable explanation of the discrepancy is that the stars really have small but sensible proper-motions. If these are distributed in a random manner, the square of the observed average p.m. will be equal to the sum of the squares of the average real p.m. and the accidental error. Thus the outstanding average proper-motions given in the last column, are determined.

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* Nos. 5, 6, 33, 50 and 52.

The observed proper-motions, *by themselves*, can be represented as the results of accidental error about as well as the parallaxes. The average error of a single plate can be found from each of the tabular quantities by multiplying it by the square-root of its weight. This gives from the parallaxes:

Group I	II	III	IV	Weighted Mean
″	″	″	″	″
0.055	0.060	0.049	0.061	0.057

and from the proper-motion:

0.061	0.066	0.058	0.072	0.064

But the two values of the average error, derived in this way, are inconsistent. There is some systematic cause of discrepancy at work, which causes the plates to agree better when the proper-motions of the stars are *eliminated*. than when they are merely assumed to be negligible; and this must almost certainly be real proper-motion.

If each of the tabular values of the real motion be given a weight proportional to the product of the number of stars in the group by the weight of an individual proper-motion, the mean is 0″.014. With this value of the average real motion, and the accidental errors given above, the observed proper-motions are represented as follows:

	Group I	II	III	IV
	″	″	″	″
Observed	0.059	0.051	0.031	0.022
Computed	0.059	0.048	0.031	0.023

The agreement is very satisfactory.

Since the observed proper-motions, upon which the above calculations are based, satisfy three conditions for every field — their sum for the north and south, and the east and west halves of the plate vanishing — the real proper-motion of the stars will, on the average, be greater than the tabular values in the ratio $\sqrt{n}\,;\sqrt{n-3}$, where n is the number of comparison-stars on the plate. The average value of n is 7.8. The average proper-motion in x of the comparison-stars, excluding the six already mentioned, is therefore $0''.014\sqrt{\frac{7.8}{4.8}}$ or 0″.017. Including the six stars it is 0″.025. The average p.m. on a great circle (if the proper-motions are distributed at random on the celestial sphere) must be $\frac{4}{\pi}$ times as great — that is, 0″.032. This determination has, of course, no great weight. The point of interest is that so small a quantity can be determined at all from observations covering only from one to three years.

The observed corrections to the catalogue proper-motions of the parallax stars — especially for the longer series — average much greater than their probable errors. In some cases they may represent errors in the catalogued values; but in others they are pretty clearly due to proper-motion of one or two comparison-stars. The introduction of proper-motion terms into the equations of condition appears therefore to be always necessary.

For one star — Groombridge 1646 — the observed p.m. in x differs by $-0''.108 \pm 0.031$ from that of Boss's *Preliminary General Catalogue*. The rejection of one comparison-star showing evidence of p.m. increases the discrepancy to $-0''.140$. It is possible that the proper-motion of this star is variable. In a letter to the writer, Professor Boss states that the meridian observations show no sign of this; but an oscillation of short period — ten years or so — and small enough amplitude to escape detection in this way, would account for the observed discrepancy.

In conclusion, it gives the writer much pleasure to express his very hearty thanks to Sir Robert Ball, Director of the *Cambridge Observatory*, for the use of its instruments and privileges, and for his cordial interest in the work; to Mr. Hinks, for much valuable comment and criticism, in addition to his invaluable and essential collaboration in the preparation of the plans and the work of observation; to Professor E. C. Pickering, for the determination of the magnitudes and spectra of nearly three hundred stars; to the authorities of *Princeton University* for the time and instrumental means for completing the work there; and to the President and Executive Committee of the *Carnegie Institution of Washington* for the grant which made the work possible, and for permission to publish this account of its results.

Princeton University Observatory, 1910 July 30.

SUNSPOT OBSERVATIONS,

MADE AT BERWYN, PENN., WITH A 4½-INCH REFRACTOR,

By A. W. QUIMBY.

1910		Time	New	Total		Fac.	Def.
			Grs.	Grs.	Spots	Grs.	
Jan.	1	8	–	4	15	1	fair
	2	12	–	3	20	1	"
	3	8	–	3	10	2	"
	4	8	–	3	8	2	"
	7	10	–	2	6	2	poor
	8	10	–	1	4	1	fair
	9	10	1	3	5	2	"
	10	8	–	1	2	3	"
	11	8	–	1	1	3	"
	12	11	–	1	1	–	poor
	13	9	–	1	1	–	"
	15	12	–	1	1	1	fair
	16	8	–	1	1	2	"
	17	12	–	1	1	1	"
	18	11	–	1	1	–	poor
	19	8	1	1	2	2	fair
	20	8	1	3	5	3	"
	22	9	1	2	4	1	poor
	23	8	1	3	9	2	fair
	24	9	–	2	3	–	poor
	25	1	–	3	9	2	fair
	26	8	–	3	5	1	poor
	27	8	–	3	4	1	"
	28	10	–	2	3	–	"
	29	3	–	2	5	–	fair
	30	8	–	2	6	–	poor
	31	9	–	2	4	–	fair
Feb.	1	9	–	2	4	1	"
	2	8	–	2	3	1	"
	3	8	–	–	–	2	"
	4	8	–	–	–	–	"
	5	8	–	–	–	2	"
	6	8	–	–	–	–	"
	7	8	–	–	–	–	"
	8	8	–	–	–	–	"
	10	8	1	1	2	1	"
	11	3	–	1	7	1	"
	12	3	–	1	7	1	"
	13	8	1	2	8	–	"
	14	8	–	3	13	1	"
	15	8	–	2	9	–	"
	16	8	1	2	8	–	"
	17	8	–	2	9	–	"
	18	8	1	3	11	1	"
	19	8	–	3	22	1	"
	20	8	–	3	16	1	"
	21	9	1	4	20	2	"
	22	11	–	4	45	2	"
	23	8	–	3	30	2	"
	24	8	–	2	28	–	"
	25	8	–	2	22	–	"
	26	8		2	22	1	"
	27	9	1	2	20	1	poor
Mar.	2	5	–	1	6	–	fair
	3	8		1	4	–	"
	4	4	1	2	11	1	"
Mar.	5	8	–	2	12	1	fair
	6	8	–	1	4	1	"
	7	8	–	1	4	1	"
	8	8	–	1	1	1	"
	9	8	1	1	4	–	"
	11	8	1	2	8	1	"
	12	2	–	2	5	–	"
	13	8	–	1	4	–	"
	14	8	–	1	4	–	"
	15	8	1	2	5	1	"
	16	8	–	2	5	1	"
	*17	12	–	2	4	–	poor
	*18	8	–	2	5	–	fair
	19	8	–	2	4	–	"
	20	8	–	2	3	1	"
	21	8	–	2	3	2	"
	22	8	–	2	3	2	"
	23	8	–	2	2	1	"
	24	8	1	2	2	2	"
	25	8	1	3	4	2	"
	26	8	–	2	3	2	"
	27	7	–	2	3	1	"
	28	7	–	1	1	–	"
	29	7	–	1	1	1	"
	30	7	–	1	1	–	"
	31	7	–	1	1	–	"
Apr.	1	7	–	1	1	–	"
	2	7	–	1	1	–	"
	3	7	–	1	1	1	"
	4	1	–	–	–	1	"
	5	7	–	–	–	–	"
	6	7	–	–	–	–	"
	7	2	–	–	–	–	"
	8	9	–	–	–	–	"
	9	7	1	1	1	1	"
	10	7	–	1	1	1	"
	11	7	–	1	1	–	"
	12	10	–	1	1	–	"
	13	7	–	1	1	1	"
	14	7	–	1	2	–	"
	15	7	–	1	2	–	"
	16	7	2	3	10	–	"
	18	2	–	–	–	–	"
	19	7	1	1	3	1	"
	20	7	–	1	3	1	"
	21	7	–	1	1	1	"
	22	7	–	0	0	0	"
	23	7	1	1	1	1	"
	25	7	–	–	–	–	"
	26	7	–	–	–	–	"
	27	7	–	–	–	–	"
	28	7	–	–	–	–	"
	29	7	1	1	3	1	"
	30	7	1	1	5	1	"
May	1	7	–	1	4	1	"
	2	7	–	1	4	–	"
May	3	9	–	1	2	–	poor
	4	8	–	1	7	1	fair
	5	7	–	1	6	1	"
	6	7	–	1	5	–	"
	7	7	–	1	2	–	"
	8	12	–	–	–	–	poor
	9	9	1	2	6	2	fair
	10	7	–	2	2	1	"
	11	3	–	1	1	–	poor
	12	3	1	2	2	1	fair
	13	7	–	2	2	1	"
	14	7	1	3	7	1	"
	15	7	–	3	11	1	"
	16	7	–	3	11	1	"
	17	7	–	3	12	1	"
	18	7	1	4	13	1	"
	19	7	–	4	15	1	"
	20	7	–	3	17	1	"
	21	3	–	3	7	1	"
	23	3	–	1	2	1	"
	24	7	–	1	1	1	"
	25	4	–	–	–	–	"
	26	7	1	1	2	1	"
	27	7	–	1	2	1	"
	28	7	–	1	3	1	"
	29	6	–	1	3	–	"
	30	6	–	1	6	–	"
	31	9	–	1	4	–	"
June	1	7	–	1	5	–	"
	2	6	–	1	6	1	"
	3	5	–	1	5	–	"
	4	6	–	1	6	1	"
	5	7	–	–	–	–	poor
	6	6	1	1	1	1	fair
	7	6	–	1	3	1	"
	8	8	–	1	1	1	"
	9	6	–	–	–	1	"
	12	1	–	–	–	–	poor
	13	1	–	–	–	–	"
	14	9	–	–	–	–	"
	15	6	–	–	–	1	fair
	16	4	–	–	–	–	"
	17	4	1	1	2	1	"
	18	7	–	1	1	1	"
	19	6	–	–	–	–	"
	20	6	–	–	–	1	"
	21	6	–	–	–	1	"
	22	6		–	–	1	"
	23	6		–	–	–	"
	24	6	1	1	2	1	"
	25	6		1	2	1	"
	26	6	1	2	15	2	"
	27	6	–	2	21	1	"
	28	11	–	2	5	2	"
	29	6	–	1	2		"
	30	6	–	1	2	1	"

*2½″ refractor.

OBSERVATIONS OF HALLEY'S COMET,

MADE AT NEWTON OBSERVATORY, ALLEGHENY COLLEGE, MEADVILLE, PA.,

By CHARLES J. LING.

The following observations were made with the Carter Micrometer on the nine-inch equatorial. The right ascensions are chronographic, except on May 3, which are micrometric. The declination bisections were obtained while the comet and stars were drifting through the field.

Meadville M.T.	*	Comp.	Δα	Δδ	App. α	App. δ	log pΔ		Red. to App. Pl.	
1910 h m s			m s	′ ″	h m s	° ′ ″			s	″
Jan. 8 10 0 54	1	15 , 6	−0 22.97	+ 4 45.7	1 53 17.76	+10 26 2.2	9.532	0.694	−0.63	−2.7
Feb. 1 7 49 0	2	20 , 4	+0 29.89	− 3 15.3	1 2 28.92	+ 8 19 48.7	9.548	0.714	−1.20	−5.5
1 8 8 15	3	20 , 6	+0 16.80	+ 9 34.7	1 2 28.11	+ 8 19 47.0	9.575	0.721	−1.21	−5.6
4 7 23 6	4	20 , 6	−0 20.81	+ 5 25.9	0 58 21.22	+ 8 12 18.3	9.534	0.718	−1.25	−5.9
4 7 43 19	5	20 , 6	−0 26.02	− 6 2.9	0 58 18.78	+ 8 12 15.1	9.576	0.720	−1.25	−5.9
May 3 16 5 23	6	0 , 3	....	+ 7 53.8	....	+ 8 35 16.3	....	0.742	.	−7.1
3 16 11 19	6	3 , 0	+0 0.76	....	23 57 47.37	....	9.634*n*	....	−1.04	...
4 16 6 37	7	10 , 3	+1 39.39	+ 8 36.8	0 0 2.17	+ 8 46 53.9	9.634*n*	0.740	−1.03	−7.5
25 8 26 25	8	15 , 6	−0 30.20	− 8 43.2	8 51 17.45	+ 7 36 52.4	9.568	0.723	−0.22	+1.0
25 8 50 35	9	20 , 6	−3 31.91	+ 5 54.8	8 51 34.85	+ 7 35 9.5	9.594	0.730	−0.20	+0.9
26 10 7 12	10	20 , 8	−0 19.70	+ 0 4.8	9 8 18.13	+ 6 11 16.1	9.636	0.752	−0.13	+0.2
26 10 23 10	11	20 , 8	−0 52.27	− 7 8.5	9 8 27.10	+ 6 10 22.4	9.641	0.755	−0.13	+0.3
27 8 45 58	12	20 , 8	+0 26.10	+ 1 2.8	9 20 8.83	+ 5 10 8.6	9.564	0.737	−0.08	−0.2
27 9 14 57	13	20 , 6	−3 9.67	− 6 45.6	9 20 22.10	+ 5 9 5.0	9.596	0.742	−0.03	−0.2
28 8 37 29	14	20 , 8	−0 27.89	− 1 12.9	9 30 16.00	+ 4 17 22.6	9.543	0.741	−0.03	−0.6
28 8 54 35	15	20 , 6	+1 33.87	+ 4 0.8	9 30 21.94	+ 4 16 37.6	9.566	0.743	+0.04	−0.6
June 6 9 4 13	16	15 , 6	−0 54.67	+ 7 23.0	10 14 7.80	+ 0 21 52.7	9.642	0.764	+0.10	−2.3
6 9 24 4	17	15 , 6	−2 36.31	+ 7 46.1	10 14 9.87	+ 0 21 40.3	9.587	0.764	+0.10	−2.4
7 9 7 33	18	20 , 6	−1 48.67	+ 2 23.3	10 16 37.48	+ 0 8 19.1	9.573	0.764	+0.11	−2.4
7 9 17 53	19	19 , 6	−3 36.09	+ 4 56.5	10 16 39.02	+ 0 8 13.2	9.585	0.762	+0.12	−2.5

Mean Places of Comparison-Stars for 1910.0.

*	α	δ	Authority		*	α	δ	Authority	
	h m s	° ′ ″				h m s	° ′ ″		
1	1 53 41.36	+10 21 19.2	A.G. Leipzig I	589	11	9 9 19.50	+ 6 17 30.6	A.G. Leipzig II	5014
2	1 2 0.23	+ 8 23 9.5	" Leipzig II	401	12	9 19 42.81	+ 5 9 6.0	" "	5103
3	1 2 12.52	+ 8 10 17.9	" "	404	13	9 23 31.80	+ 5 15 50.8	" "	5132
4	0 58 42.96	+ 8 6 57.7	" "	378	14	9 30 43.92	+ 4 18 34.1	" Albany	3819
5	0 58 45.73	+ 8 18 23.6	" "	379	15	9 28 48.11	+ 4 12 37.4	" "	3810
6	23 57 47.65	+ 8 27 29.6	" "	11858	16	10 15 2.37	+ 0 24 32.0	" Nicolajew	3035
7	23 58 23.81	+ 8 38 24.6	" "	11864	17	10 16 46.08	+ 0 13 56.6	" "	3040
8	8 51 47.87	+ 7 45 34.6	" "	4884	18	10 18 26.04	+ 0 5 58.2	" "	3046
9	8 55 6.96	+ 7 29 13.8	" "	4907	19	10 20 14.99	+ 0 3 19.2	" "	3055
10	9 8 37.96	+ 6 11 11.1	" "	5006					

Allegheny College, Meadville, Pa., 1910 *Sept.* 12.

OBSERVATION OF COMET *c* 1910 (*D'ARREST*),

MADE WITH THE 26-INCH EQUATORIAL AT THE U.S. NAVAL OBSERVATORY,

By J. B. EPPES.

[Communicated by Commodore T. E. De Witt Veeder, U. S. N. Superintendent.]

1910 Wash.M.T.	Comp.	Δα	Δδ	App. α	App. δ	log pΔ		Red. to App. Pl.	
h m s		m s	′ ″	h m s	° ′ ″			s	″
Aug. 30 9 26 25	25 , 5	−4 4.90	−0 26.5	16 59 20.78	−11 55 28.4	9.520	0.805	+1.60	+4.2

Mean Place of Comparison-Star for the beginning of the Year.

α	δ	Authority
h m s	° ′ ″	
17 3 24.08	−11 54 57.7	Radcliffe 4456

Note. Comet extremely faint. Poor observation.

NOTE ON *BD* +33° 4426,

RA. $22^h\ 0^m\ 18^s.5$; Decl. 33° 56′.4 (1855),

By PAUL S. YENDELL.

This star is about 5′ north and 9^s following BD + 33°4424, which I have used as a comparison-star for 1.1910, and is given in the DM as $9^M.5$.

I have observed it on eight evenings, from Aug. 30 to Oct. 3 of the present season, always near the limit of vision of the $4\frac{1}{4}$-inch telescope, power 30, with which I have been observing. It is too faint for profitable use of comparison-stars, but the eye-estimate recorded on each evening is 11^M.

Dorchester, Mass., 1910 *Oct.* 8.

EPHEMERIS OF 620 *DRAKONIA*. OPPOSITION, 1910,

By LEROY P. STEELE.

1910 G.M.T.		α (1910.0)	δ (1910.0)	log *r*	log Δ
		h m s	° ′ ″		
Nov.	9.0	5 2 8.8	+34 3 6	0.382115	0.182133
	17.0	4 54 29.1	34 22 17	0.384263	0.172982
	25.0	4 45 20.7	34 30 15	0.386394	0.168298
	29.0	4 40 26.9	34 29 34	0.387453	0.167819
Dec.	3.0	4 35 28.8	34 25 46	0.388506	0.168639
	7.0	4 30 33.4	34 18 58	0.389554	0.170781
	11.0	4 25 47.4	34 9 26	0.390596	0.174184
	19.0	4 17 7.4	33 43 39	0.392661	0.184627
	27.0	4 10 7.5	+33 11 53	0.394701	0.199339

Dec. 3 For $\Delta M = +1°$; $\Delta\alpha = +^{s}.559$, $\Delta\delta = +16'.2$

The above places were computed from the elements given in the *Berliner Jahrbuch* and furnished the writer by the discoverer of this asteroid, Rev. JOEL H. METCALF, of Taunton, Mass. No account has been taken of perturbations, and therefore the computed places are liable to differ from the true positions by considerable amounts.

Drakonia is variable, having been so reported by Rev. JOEL H. METCALF in the same year with its discovery (1906).

Wallingford, Conn.

ELEMENTS AND EPHEMERIS OF COMET *b* 1910 (*METCALF*).

By ETTA M. EATON.

[Communicated by Commodore T. E. DE WITT VEEDER, U. S. Navy, Superintendent.]

From observations made at Lick, Ladd, and Nice on Aug. 12, at Nice and Rome on Aug. 21, and at Washington on Aug. 30, 1910, the following parabolic elements have been computed:

$$T = 1910 \text{ Sept. } 16.61652 \text{ G.M.T.}$$

$$\left.\begin{aligned} \omega &= 51^\circ\ 8'\ 9''.2 \\ \Omega &= 289\ 30\ 22.2 \\ i &= 121\ 2\ 27.5 \end{aligned}\right\}\ 1910.0$$

$$q = 1.94835$$

The residuals O—C for the middle place are

$$\cos\beta\ .\ \Delta\delta = -8''.6\ ,\quad \Delta\beta = -0''.7.$$

A comparison of the observations made at Washington on Sept. 26, 28, give the following residuals:

$$\cos\beta,\ \Delta\lambda = +15''.2\ ,\ +17''.5\quad ;\quad \Delta\beta \doteq +1''.2\ ,\ +0''.8$$

HELIOCENTRIC COORDINATES, 1910.0.

$$x = r\,[9.770630]\sin(196^\circ\ 38'\ 52''.1 + v)$$
$$y = r\,[9.999287]\sin(291\ \ 9\ \ 7.7 + v)$$
$$z = r\,[9.908298]\sin(\ 23\ 32\ \ 4.5 + v)$$

EPHEMERIS FOR 1910.

G.M.T.		App. α	App. δ	log Δ
		h m s	° ′ ″	
Oct.	27.5	15 29 45.7	+19 50 7	0.42989
	31.5	15 30 58.4	20 14 41	0.43250
Nov.	4.5	15 32 17.3	20 41 55	0.43435
	8.5	15 33 41.5	21 12 3	0.43546
	12.5	15 35 9.8	21 45 21	0.43584
	16.5	15 36 41.3	22 21 58	0.43554
	20.5	15 38 15.0	23 2 17	0.43456
	24.5	15 39 49.8	23 46 28	0.43294
	28.5	15 41 25.0	+24 34 53	0.43068

U.S. Naval Observatory.

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SYSTEMATIC PROPER–MOTIONS OF STARS OF TYPE B,

By BENJAMIN BOSS.

In the month of December, 1909, I undertook a search for star-streams, using the material prepared by the Department of Meridian Astrometry of the Carnegie Institution of Washington, under the direction of Prof. LEWIS BOSS.

Although this work constitutes a part of the studies of sytematic proper-motions, contained in the *Preliminary General Catalogue of* 6188 *Stars*, of this Department, the necessity of laying out work upon reductions of meridian-observations for a large force of computers, confined the search for star-streams to the evening hours. Consequently the progress was slow.

At first only those stars whose proper-motions amounted to 10″ a century, or more, were considered, but as no striking cases of streams, with numerous membership, appeared among them, apart from those already known, the search was continued to smaller proper-motions.

There were several promising groups of these, and in January, 1910, two groups were specially noticed. The first was in R.A. 12^h to $14^h\ 30^m$, declination $-40°$ to $-60°$ (see Fig. 1), and the second in R.A. 3^h to 4^h, declination $+20°$ to $+50°$ (see Fig. 2). Upon examining these for spectral type, the B stars stood out so prominently that at first there seemed little doubt but that these apparent streams were largely formed of stars of type B. On consulting Professor Boss, I was advised to continue the investigation in other instances. He was strongly of the opinion that the apparent stream-motion was mostly parallactic. This I found to be the case, but I was obliged to drop the matter for the time being without preparing it for publication. Recently opportunity has been given me to prepare a statement in regard to the material I had collected, under the circumstances already narrated.

The nature of the phenomena under consideration, can best be illustrated by the two diagrams accompanying this communication. Conceive all the stars within a given area to be transferred to a single point, at the initial epoch. Then the effect of centennial proper-motion, can be illustrated by supposing the several stars to radiate from this initial point by amounts and in directions, corresponding to the actual centennial motions, as they have been computed for each star. Thus, instead of constituting a single point at the origin, as they are supposed to do at the initial epoch, at the end of a century they will form a schematic group as represented in the diagrams. The motions, not exceeding 19″ per century, embraced in Fig. 1, are contained within the limits 12^h to $14^h\ 30^m$ in R.A. and $-40°$ to $-60°$ in declination. In like manner, motions in the area R.A. 3^h to 4^h, declination $+20°$ to $+50°$, were used to form Fig. 2.

The proper-motions used were those of the *P.G.C.* corrected for revised precession and motion of the equinox, according to the formulas on p. XXVIII of the Introduction to the *P.G.C.* The position angles, θ_A, of the motion are computed with reference to the Apex of Solar Motion as determined in *A.J.*, No. 614. Adopted position of the Apex is R.A. = 270°.52; declination = +34°.28.

In Figures 1 and 2, the Apex of Solar Motion is in the direction of 0°, the Antapex being toward 180°.

The spectral types of the stars are indicated from the determinations contained in the Revised Harvard Photometry (*Annals of H.C.O.* Vol. L). All stars of the *P.G.C.* in these regions are shown in order to exhibit the peculiarities of arrangement of the motions of the stars, of types B and A, in comparison with all the remaining types.

The following symbols have been used in the diagrams: A black dot is employed for the helium stars — types lying between the limits Oe5 and B5 inclusive (Revised Harvard Photometry). The mark + is employed for the stars between types B8 and A5; and circles indicate stars of the other types F to M. B8 and B9 have been included in type A (not in B) in this discussion, because of their nearer resemblance to the A stars, as demonstrated both by their spectra and by their mean motions.

It requires but a glance at the diagrams to see that, whereas, the motions of stars of type A, F, G, and K are widely diffused in position-angle, those of type B are confined to comparatively narrow limits. In fact there are only ten B stars in the *P.G.C.* (not rejected for large probable error of motion), whose centennial proper-motions amount to 6″.0 or more; and only five of these amount to 7″.0 or more.

It may likewise be seen from the diagrams that when allowance has been made for parallactic motion due to the Sun's motion, the residual, or peculiar, motion of the B stars is exceedingly small. This fact has previously been rendered probable, as to radial motions, by FROST and ADAMS in *The Decennial Publications of the University of Chicago*, Vol. VIII, and later by KAPTEYN and FROST in *The Astrophysical Journal*, Vol. XXXII, No. 1.

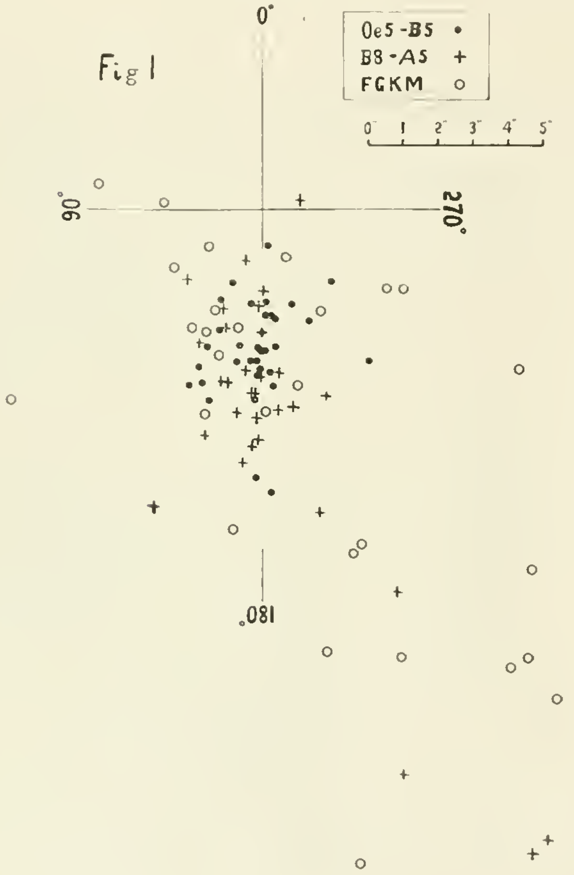
Fig 1

Referring to Figure 2, we see that the motions of B stars, in this area, seem to be grouped mainly in two divisions, and this points strongly toward the possibility of minute differences of drift between groups of B stars. There seems to be a tendency toward clustering in position on the sky of a large percentage of the B stars. The frequency with which such groups are met, would admit of the belief that separate clusters have been formed, with possibly an individual drift-motion in each. For instance, in the case of the stars in Fig. 2, the motions of six of them, in mean position-angle 188°, arise from the *Pleiades*: while the stars of a coarse cluster in *Perseus* (at $3^h\ 20^m$, $+49°$) have a common motion in the general position-angle 163°. There are other comparatively compact clusters at $5^h\ 30^m$, $-6°$; at $8^h\ 6^m$, $-47°$; at $10^h\ 40^m$, $-64°$; at $22^h\ 30^m$, $+39°$; and there are several others.

Then there are stars more widely scattered on the face of the sky, which, neverthless, seem to indicate a distinct cluster-formation.

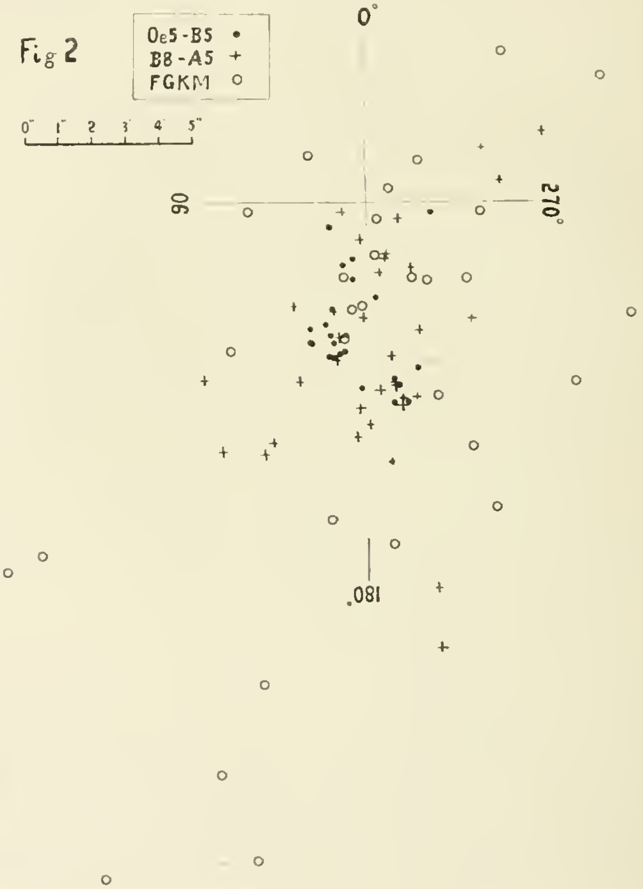
Fig 2

The proper-motions of the B stars are very small, and this proper-motion is almost entirely parallactic. Thus, we must deal with peculiar motions so minute that it is difficult to recognize with certainty any common drift, or other singularities in relation to them. The probable error of determination of these motions is often comparable with the peculiar motions themselves, especially south of −30° of declination.

At this point, it might be well to caution against over-reliance on the systematic accuracy of proper-motions as given in the catalogues of fundamental systems.

According to current estimates at this observatory, it is easily possible that, for limited areas, there may be systematic errors of the centennial motions amounting to 0″.4, or more. Reference to the writer's comparison of the Standard Catalogues of AUWERS and BOSS (*A.J.*, 615), shows occasional systematic discrepancies between the centennial motions of the two of 1″.0 or more, south of −30° of declination. In the cases of the smaller of these proper-motions of B stars, a systematic change of 0″.4 would have a pronounced effect on the position-angles of these motions. Even where the motions amount to as much as 4″.0, a change of 0″.4 in either component of the proper-motion may change the position-angles several degrees, −6° in an unfavorable case.

TABLE I. GROUPS OF HELIUM-STARS HAVING LARGE PARALLACTIC MOTIONS.

No. ✱✱	1875 R.A.	1875 Decl.	Δ	μ_0	θ_A	Obs. π	Limits of θ_A	No. ✱✱	Gal. Lat.	Discordant θ_A
	h	°	°	″	°	″	° °		°	° °
10	0.8	+58	67	2.53	167	2.38	140–189	8	+ 6	283, 122
12	3.4	+51	88	3.80	162	3.79	155–171	12	− 4	—
14	3.6	+29	108	3.90	182	3.64	164–197	12	−19	123, 262
5	4.7	+42	102	4.96	158	3.96	154–171	4	− 1	24
3	10.8	−80	127	4.63	178	4.58	162–206	3	−18	—
9	12.6	−49	111	4.04	176	3.83	157–197	8	+14	223
23	12.7	−61	115	3.55	172	3.37	147–196	20	+ 2	221, 123, 242
24	14.3	−42	92	4.10	180	3.98	155–196	24	+17	—
13	15.3	−57	97	3.22	182	2.78	156–215	11	0	225, 134
17	15.8	−30	72	3.93	176	3.82	165–189	16	+18	147
9	16.2	−19	59	2.66	167	2.13	158–192	8	+20	15
18	16.7	−42	78	3.43	184	3.18	161–218	16	+ 1	143,63
5	18.9	−34	69	4.14	174	3.95	135–186	5	−17	—
						Pleiades.				
6	3.6	+24	113	5.57	188	5.55	178–197	6	−23	—
						A CLUSTER IN *Perseus.*				
8	3.3	+49	89	4.36	163	4.34	152–171	8	− 6	

When, in addition to systematic error, account must be taken of the accidental errors, it can be seen that only an approximate idea of the character of the peculiar motions of the B stars can be obtained. Therefore, in Table I, where it is intended to give some idea of the systematic motions of the B stars, only those regions containing stars of maximum motion have been presented. The headings of the first three columns are self-explanatory — the right-ascensions and declinations given being the means of the right-ascensions and declinations of all the stars in the several areas. In the fourth column, Δ, is the distance of the mean of the stars in the area concerned from the apex of solar motion. In the fifth column the proper-motions have been corrected as in the tables leading to Figures 1 and 2. In the sixth column the position-angles are with reference to the apex of solar motion. The seventh column, Obs. π, contains the observed parallactic motion for each area. The eighth column gives the limits between which lie the position-angles of the majority of

TABLE II. HELIUM-STARS NEAR ANTAPEX.

No. P.G.C.	1875 R.A.	1875 Decl.	$\mu \cos \delta$	Wt.	μ'	Wt.	μ_0	θ_A
	h m	°	″		″		″	°
1401	5 35	−34.2	+0.8	2.0	−3.5	1.3	3.6	253.8
1467	5 49	−33.8	+0.5	.1	+2.8	.2	2.8	90.0
1490	5 53	−35.3	0.0	.6	+0.2	.7	0.2	117.8
1532	6 3	−34.3	0.0	.1	0.0	.2	0.0	—
1601	6 16	−30.0	+1.2	1.1	+0.1	1.0	1.2	52.3
1605	6 16	−34.1	+0.3	.1	+2.5	.2	2.5	281.7
1641	6 24	−32.5	−2.4	.4	+1.6	.5	2.9	227.2
1642	6 24	−32.3	−1.0	.2	+0.9	.2	1.4	245.9
1669	6 28	−31.9	+0.7	.1	+0.1	.2	0.7	17.0
			+0.01		−0.52			

TABLE III. HELIUM-STARS NEAR APEX.

No. P.G.C.	1875 R.A.	1875 Decl.	$\mu \cos \delta$	Wt.	A′	Wt.	μ_0	θ_A
	h m	°	″		″		″	°
4388	17 13	+33.2	−1.6	.8	−1.3	.9	2.1	149.8
4427	17 20	+20.2	+1.4	.4	+1.2	.4	1.8	18.2
4479	17 36	+46.1	−0.4	2.5	−0.2	4.1	0.4	88.2
4514	17 47	+48.4	+0.1	.6	+0.8	.8	0.8	200.1
4562	17 57	+20.8	+0.3	.4	−1.8	.7	1.8	167.9
4590	18 3	+20.8	+0.3	.4	−1.7	.4	1.7	173.0
4620	18 12	+42.1	−0.2	.6	−0.7	.7	0.7	1.5
4772	18 45	+32.7	+0.5	.7	−1.4	.9	1.5	238.4
4776	18 45	+33.2	+0.8	4.8	−0.7	5.7	1.1	212.2
4794	18 49	+36.8	−0.3	.4	−0.9	.5	1.0	298.8
			+0.09		−0.67			

the proper-motions in each area. The next column indicates the actual number of proper-motions corresponding to the limits. Then come the Galactic latitudes, and in the last column are the values of θ_A lying outside the limits described in column eight.

Each area in Table I contains all the motions of B stars that have probable errors less than about $\pm 1''.2$, within the boundaries of a square whose sides approximate 20°. Table I shows very clearly, by comparing the column, μ_0, with the Obs. π, and by noting the position-angles of the mean proper-motions, that nearly all the proper-motion is parallactic. Of course when the deviations of the θ_A from 180° become as large as they are in the cases of a few of the areas dealt with, there is always the possibility that there may be drift-motion of the stars themselves. For instance, in the cases of the areas in Table I, in the second and fourth lines, where the deviations of θ_A from 180° are 18° and 22° respectively, with the mean of the proper-motions amounting to $3''.80$ and $4''.96$, it would take a change of $0''.9$ in each component of the motion to bring the θ_A to 180°. It is scarcely possible that the probable errors of the individual stars, combined with the systematic error, for this region of sky, might amount to $0''.9$ in each coordinate; so that in these two groups there is very fair evidence of drift-motion. In the cases of the other groups the deviations of the proper-motions from 180° are entirely within the possibilities of the probable errors, — systematic and accidental.

It is of interest to note the small range of the position-angles in each area. In fact, in all the areas in Table I, there are only six stars outside of the quadrant 134°–224°. The brute mean of the position-angles in Table I is 174°, that of the mean proper-motions is $3''.76$, and that of the observed parallactic motions is $3''.49$.

At the bottom of Table I the data concerning the *Pleiades* has been placed and, below, that of another group 25° north of the *Pleiades*. There would appear to be a relative drift between these two groups, because of the great uniformity of the motions in one direction within each of the drifts. (See Fig. 2.)

All the regions discussed in Table I are at large distances from the Apex of Solar Motion. It would be interesting, therefore, to see what the regions around the Apex and Antapex show, where parallactic motion is at its minimum. Tables II and III represent respectively the region around the Antapex and the Apex of Solar Motion. In the case of the region near the Antapex, there is a group of stars extending over it, but the B stars are more widely scattered at the Apex. There may be a minute drift in these areas, but this may be considered doubtful.

It has already been pointed out that the motions are exceedingly small, there being but five cases where the proper-motion exceeds $7''.0$. One of these, standing by itself, is *α Gruis*, *P.G.C.*, 5684, B5, which has a proper-motion of $20''.2$. The tendency towards clustering of the stars as seen on the sky has also been spoken of. Although this tendency is quite pronounced all through the region occupied by the B stars, it is more especially so in a strip extending from Galactic long. 205°* to long. 260° where the B stars are to be found in greatest numbers.

The whole type seems to be mainly confined within very narrow limits. A belt 25° wide would include almost all of the B stars. This belt will approximately follow the Galactic equator (in the mean, somewhat south), excepting that between long. 130° and 210° there is a tendency to run about 20° south of it, while between 290° and 325° there is a tendency to run about 10° north of it.

Professor Boss has kindly given me, in advance of publication, the results of his investigation of solar motion as derived from the B type stars. It places the Apex of Solar Motion at R.A. = 274°.2, declination = + 36°.1. The Apex, as derived from the General Solution by him in *A.J.*, 614, is placed at R.A. = 270°.52, declination +34°.28. The slight deviation between these two results would indicate that there can be practically no general systematic drift among the B stars, unless such drift is shared in equal proportions among stars in general.

The mean motion of the B stars is $2''.40$ while the mean parallactic motion, at 90° from the solar apex, amounts to $2''.74$. This gives the ratio, $\frac{\mu_0}{M}$ equal to 0.88 instead of 1.40, as it comes out from the General Solution (*A.J.*, 614, p. 112).

The stars of types B8 and B9 have been included among the A stars, as more nearly belonging to that type, judging from their proper-motions. In fact a glance at Figures 1 and 2 will show a decided relationship between the stars from Oe5 to B5 inclusive, and those from B8 to A5. Later investigation by Professor Boss would seem to exclude the type A5 from classification with type A.

The frequent occurrence of great discrepancies between the parallactic motion of the B stars as derived from adjoining regions, leads to the conclusion that the stars of that type are at greatly varying distances, which suggests the wide distribution in space of these stars, though it also indicates that few of these stars are in the immediate vicinity of the Sun. In general the B stars in the vicinity of 22^h are among the more distant of their class, while those around 14^h are, in general, among the nearer stars. The volume of space near the Sun out to a radius of stars having parallactic motion of about $6''.0$, at least, seems to be void of stars of type B, except for *α Gruis* (p.m. = $20''.2$), already mentioned.

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* The zero of Galactic longitude is taken at R.A. $18^h\ 41^m\ 20^s$, and declination 0°.

TERMS OF THE SECOND ORDER IN THE MEAN LONGITUDES OF *MARS* AND THE EARTH THAT HAVE THE ARGUMENT $3J-8M+4E$.

By WILLIAM T. CARRIGAN.

Let us designate the perturbing function between two planets by the letter R, and the true longitude, log radius vector and latitude by v, ρ, β and v', ρ', β' for each planet respectively, then we have

$$R = f(v,\rho,\beta,v',\rho',\beta')$$

If the perturbations of the coordinates be designated by δv, $\delta\rho$, $\delta\beta$ and $\delta v'$, $\delta\rho'$, $\delta\beta'$ the variation of R due to these perturbations will be given by

$$(1)\ \delta R = \frac{\partial R}{\partial v}\delta v + \frac{\partial R}{\partial\rho}\delta\rho + \frac{\partial R}{\partial\beta}\delta\beta + \frac{\partial R}{\partial v'}\delta v' + \frac{\partial R}{\partial\rho'}\delta\rho' + \frac{\partial R}{\partial\beta'}\delta\beta'$$

Denoting the undisturbed mean motion and mean distance of the perturbed planet by n_0 and a_0 respectively, and the true or disturbed mean motion and mean distance by n and a, we have the relation

$$n^2a^3 = n_0^{\,2}a_0^{\,3}$$

Taking $a = a_0 + \delta a$ this becomes

$$n^2(a_0+\delta a)^3 = n_0^{\,2}a_0^{\,3}, \text{ and } n = \frac{n_0}{\left(1+\dfrac{\delta a}{a_0}\right)^{\frac{3}{2}}} = n_0\left(1 - \frac{3}{2}\frac{\delta a}{a_0} + \right)$$

But (Cheyne's Planetary Theory, p. 35),

$$\frac{\delta a}{a_0} = \frac{2n_0a_0}{\mu}\int\frac{\partial R}{\partial\epsilon}dt\,,$$

whence, since $\dfrac{\partial R}{\partial\epsilon} = \dfrac{\partial R}{\partial g}$,

$$(2)\qquad n = n_0\left(1 - \frac{3n_0a_0}{\mu}\int\frac{\partial R}{\partial g}dt\right).$$

Now when the mean motion is considered variable we have for the mean longitude l the following expression

$$(3)\qquad l = \int ndt + \epsilon\,.$$

Wherein ϵ is the longitude of the epoch.

By differentiating (3) twice we get

$$\frac{d^2l}{dt^2} = \frac{dn}{dt},$$

but, by (2)

$$\frac{dn}{dt} = -\frac{3n_0^{\,2}a_0}{\mu}\frac{\partial R}{\partial g},$$

or

$$\frac{d^2l}{dt^2} = -\frac{3n_0^{\,2}a_0}{\mu}\frac{\partial R}{\partial g}.$$

Taking the variations of l and R in this last equation we have

$$\frac{d^2\delta l}{dt^2} = -\frac{3n_0^{\,2}a_0}{\mu}\frac{\partial\,\delta R}{\partial g}. \qquad (4)$$

Differentiating (1) with respect to the mean anomaly, leaving out the terms involving the latitude, since these are unimportant to the purpose in hand, we have

$$\left.\begin{aligned}\frac{\partial\,\delta R}{\partial g} &= \frac{\partial^2R}{\partial v\partial g}\delta v + \frac{\partial^2R}{\partial\rho\partial g}\delta\rho + \frac{\partial^2R}{\partial v'\partial g}\delta v'\\ &+ \frac{\partial^2R}{\partial\rho'\partial g}\delta\rho' + \frac{\partial R}{\partial v}\frac{d\delta v}{ndt} + \frac{\partial R}{\partial\rho}\frac{d\delta\rho}{ndt}.\end{aligned}\right\} \qquad (5)$$

This value of $\dfrac{\partial\,\delta R}{\partial g}$ substituted in (4) will give the differential equation for the perturbations of the mean longitude of the second order as to the masses.

Since the developments of $\dfrac{\partial^2R}{\partial g\partial v}$ etc., consist of series of terms whose arguments are combinations of the multiples of the mean anomalies of two planets, while those of the perturbations δv etc., though similar in form, may or may not be functions of both of the preceding mean anomalies, the multiplication of the series will produce terms whose arguments will contain two or three constituents according as the former or latter condition in the series for the perturbations obtains. Thus if the arguments of $\dfrac{\partial^2R}{\partial v\partial g}$ as well as of δv are functions of g_3 and g_2, say, the resulting combinations will contain only g_3 and g_2; while if $\dfrac{\partial^2R}{\partial v\partial g}$ is a function of g_3 and g_2, while δv is a function of g_2 and g_1, the multiplication will produce arguments of three constituents of the form $i_3g_3+i_2g_2+i_1g_1$. In general the coefficients of the resulting terms are very small, but cases occur, particularly in the combinations of three planets, where, by reason of the magnitude of the integrating factors, the terms become important. Of this nature are the terms which it is proposed to compute, namely, those having the argument $3J-8M+3E$, J, M, E

being the mean anomalies of *Jupiter*, *Mars* and Earth respectively.

The development of R and its derivatives which we shall use is that of NEWCOMB, given in Vol. III., part V, of the *Astronomical Papers of the American Ephemeris*. For each action the page from which the data is taken will be indicated. For convenience I have made some changes in the symbolization of the various quantities.

These changes are as follows:

The quantities in the columns headed V_c and V_s, which are really $\frac{\partial R}{\partial v_c}$ and $\frac{\partial R}{\partial v_s}$, I will designate as h and k respectively, those in the columns headed DH_c and DH_s, which are $\frac{\partial R}{\partial \rho_c}$ and $\frac{\partial R}{\partial \rho_s}$, I will call H and K, while δv_c and δv_s will be called a and b, and $\delta\rho_c$, $\delta\rho_s$ will, after division by the modulus of common logarithms and the sine of one second, be designated by A and B. In addition I will indicate the mean anomaly of the Earth by g_1, that of *Mars* by g_2 and of *Jupiter* by g_3.

To obtain the second-order perturbations of *Mars* due to the combined actions of the Earth and *Jupiter* and producing terms with the above argument there are three combinations to be considered, namely:

I. The action of the Earth on *Mars* as modified by the perturbations of *Mars* by *Jupiter*. The type of these terms in (5) will be $\frac{\partial^2 R_1}{\partial v_2\, \partial g_2}\,\delta v_{3.2}$.

II. The action of *Jupiter* on *Mars* as modified by the perturbations of *Mars* by the Earth. The type is $\frac{\partial^2 R_3}{\partial v_2\, \partial g_2}\,\delta v_{1.2}$.

III. The action of the Earth on *Mars* as affected by the perturbations of the Earth by *Jupiter*. The type is $\frac{\partial^2 R_2}{\partial v_1\, \partial g_2}\,\delta v_{3,1}$.

To show the manner in which the terms having the argument $3g_3 - 8g_2 + 4g_1$ are produced we will take the case I above, namely, for the action of the Earth on *Mars* as modified by the perturbations of *Mars* by *Jupiter*. Thus for the action of the Earth on *Mars* we have

$$(\alpha) \qquad \frac{\partial R}{\partial v} = h \cos\,(i_2 g_2 + i_1 g_1) + k \sin\,(i_2 g_2 + i_1 g_1)$$

$$(\beta) \qquad \frac{\partial R}{\partial \rho} = H \cos\,(i_2 g_2 + i_1 g_1) + K \sin\,(i_2 g_2 + i_1 g_1)$$

For the perturbations of the true longtiude and log radius vector of *Mars* by *Jupiter* we have:

$$(\gamma) \qquad \delta v = a \cos\,(j_3 g_3 + j_2 g_2) + b \sin\,(j_3 g_3 + j_2 g_2)$$

$$(\delta) \qquad \delta\rho = A \cos\,(j_3 g_3 + j_2 g_2) + B \sin\,(j_3 g_3 + j_2 g_2)$$

Differentiating (α) and (β) with respect to the mean anomaly of *Mars*, or g_2, we get

$$\frac{\partial^2 R}{\partial v\, \partial g_2} = -\, i_2 h \sin\,(i_2 g_2 + i_1 g_1) + i_2 k \cos\,(i_2 g_2 + i_1 g_1) \quad (\alpha)_1$$

$$\frac{\partial^2 R}{\partial \rho\, \partial g_2} = -\, i_2 H \sin\,(i_2 g_2 + i_1 g_1) + i_2 k \cos\,(i_2 g_2 + i_1 g_1) \quad (\beta)_1$$

Differentiating (γ) and (δ) with respect to the time and putting q for $j_3 n_3 + j_2 n_2$ we get

$$\frac{d\,\delta v}{dt} = -\, a q \sin\,(j_3 g_3 + j_2 g_2) + b q \cos\,(j_3 g_3 + j_2 g_2) \qquad (\gamma)_1$$

$$\frac{d\,\delta \rho}{dt} = -\, A q \sin\,(j_3 g_3 + j_2 g_2) + B q \cos\,(j_3 g_3 + j_2 g_2) \qquad (\delta)_1$$

Multiplying $(\alpha)_1$ and (γ), $(\beta)_1$ and (δ), $(\gamma)_1$ and (α) and $(\delta)_1$ and (β) and keeping only the terms that have the argument $j_3 g_3 + (j_2 - i_2)\, g_2 - i_1 g_1$ we have

$$\frac{\partial^2 R}{\partial v\, \partial g_2}\,\delta v + \frac{\partial^2 R}{\partial \rho\, \partial g_2}\,\delta\rho + \frac{d\,\delta v}{dt}\,\frac{\partial R}{\partial v} + \frac{d\,\delta\rho}{dt}\,\frac{\partial R}{\partial \rho} =$$

$\frac{1}{2}\,(i_2 - q)\,\{(ak - bh + AK - BH) \cos N + (ah + bk + AH + BK) \sin N\}$, N being put for $j_3 g_3 + (j_2 - i_2)\, g_2 - i_1 g_1$.

The formulae for the second order perturbations for all three cases follow:

$$\left.\begin{array}{ll} \text{I.} & \delta_2 l = M\,(i_2 - q)\,\{(ak - bh + AK - BH) \cos N \\ & \qquad + (ah + bk + AH + BK) \sin N\} \end{array}\right\} (A)$$

$$\left.\begin{array}{ll} \text{II.} & \delta_2 l = M\,(i_2 + q)\,\{(bh - ak + BH - AK) \cos N \\ & \qquad + (ah + bk + AH + BK\} \sin N\} \end{array}\right\} (B)$$

$$\left.\begin{array}{ll} \text{III.} & \delta_2 l = M\, i_2\,\{(ak - bh + AK - BH) \cos N \\ & \qquad + (ah + bk + AH + BK) \sin N\} \end{array}\right\} (C)$$

M being put for $-\frac{3n^2 a}{2\mu\, \mathrm{n}^2}$, wherein $\mathrm{n} \equiv 3n_3 - 8n_2 + 4n_1$.

I

For the action of the Earth on *Mars* we need the terms whose arguments are (p. 535):

$4g_2 - 4g_1$
$5g_2 - 4g_1$
$6g_2 - 4g_1$
$7g_2 - 4g_1$

and for the perturbation of *Mars* by *Jupiter* we must use the terms with the arguments (p. 567):

$3g_3 - 4g_2$
$3g_3 - 3g_2$
$3g_3 - 2g_2$
$3g_3 - g_2$

The factor $M\ (i_2-\varphi)$ is constant for all combinations that produce N and its logarithm is 1.49147. Following is a schedule of the coefficients corresponding to the above arguments.

$g_2\ \ g_1$	h	k	H	K	$g_3\ \ g_2$	a	b	A	B
						″	″	″	″
4 − 4	+.24658	+.40004	+.57347	−.35374	3 − 4	−0.201	+0.046	+0.038	+0.156
5 − 4	+.20914	+.26867	+.39347	−.30204	3 − 3	−1.281	+0.266	+0.242	+0.987
6 − 4	+.10130	+.15692	+.15692	−.14864	3 − 2	−1.730	−1.949	−1.245	+1.054
7 − 4	+.03708	+.03054	+.04712	−.05536	3 − 1	−2.821	−1.450	−0.396	+0.818

These quantities substituted in (A) give $\delta_2 l = -33''.110 \cos N - 43''.606 \sin N$

II

From page 561 we take the h, k, H and K for the terms whose arguments are

$3g_3-4g_2$
$3g_3-3g_2$
$3g_3-2g_2$
$3g_3-\ \ g_2$
$3g_3$

and from page 541 the a, b, A and B of the terms

$4g_2-4g_1$
$5g_2-4g_1$
$6g_2-4g_1$
$7g_2-4g_1$
$8g_2-4g_1$

The values of the coefficients follow:

$g_3\ \ g_2$	h	k	H	K	$g_2\ \ g_1$	a	b	A	B
						″	″	″	″
3 − 4	+.00540	−.00174	−.00176	−.00544	4 − 4	−0.036	−0.054	−0.050	+0.032
3 − 3	+.04347	−.02015	−.02073	−.04464	5 − 4	−0.086	−0.112	−0.091	+0.069
3 − 2	+.00348	+.01381	+.01436	−.00398	6 − 4	−0.156	−0.189	−0.130	+0.110
3 − 1	−.00341	−.00263	−.00251	+.00348	7 − 4	+0.801	+0.712	+0.224	−0.243
3 0	+.00032	+.00016	+.00016	−.00031	8 − 4	+0.190	+0.148	−0.056	+0.070

Using these quantities in (B) with $\log M\ (i_2+\varphi) = 2.28969$ we get

$$\delta_2 l = -1''.665 \cos N - 2''.783 \sin N$$

III

The terms to be used for h, k, H, K, are given on page 523, while those for a, b, A, B, are taken from page 551. They are for each group respectively.

$8g_2-8g_1$	$3g_3-4g_1$
$8g_2-7g_1$	$3g_3-3g_1$
$8g_2-6g_1$	$3g_3-2g_1$
$8g_2-5g_1$	$3g_3-\ \ g_1$

The values follow:

$g_2\ \ g_1$	h	k	H	K	$g_3\ \ g_1$	a	b	A	B
						″	″	″	″
8 − 8	+.07811	+.03624	−.04267	+.09226	3 − 4	−0.005	+0.002	+0.001	+0.004
8 − 7	−.05258	−.17802	−.19983	+.05973	3 − 3	−0.162	+0.027	+0.020	+0.132
8 − 6	−.07211	+.12199	+.14064	+.08360	3 − 2	+0.071	+0.551	+0.378	−0.049
8 − 5	+.05573	−.01294	−.01469	−.06779	3 − 1	−0.031	+0.208	+0.082	+0.012

with $\log Mi_2 = 1.51809$ formula (C) gives

$$\delta_2 l = +4''.227 \cos N + 3''.699 \sin N$$

Taking the sum of all these terms we have

$$\delta_2 l = -30''.548 \cos N - 42''.690 \sin N$$

Newcomb gives

$$\delta_2 l = -33''.6 \cos N - 40''.8 \sin N$$

The discrepancy between these two results is due to some extent to an error in Professor Newcomb's computation of the terms III in Vol. V, part ii of the *Astronomical Papers* where he has neglected to divide the $\delta\rho$'s by the modulus of common logarithms.

Leverrier's value is

$$\delta_2 l = -33''.1 \cos N - 32''.2 \sin N$$

These three results reduced to 1850 are

	$+52''.5 \sin (292^\circ.65)$	$= -48''.4$
NEWCOMB	$+52.8 \sin (296.53)$	$= -47.3$
LEVERRIER	$+46.2 \sin (302.84)$	$= -38.8$

The terms in the motion of the Earth arise from (A) and (C), the data and computations being exactly the same as for *Mars* except that in (A) $(i_2-\varphi)$ becomes i_1, and in (C) i_2 becomes $(i_1+\varphi)$, while the factor M contains a and n for the Earth instead of for *Mars*. The logarithm of the multiplier in I is -0.6072, and that in III is 0.6338. Using these values we obtain from I

$$\delta_2 l = +4''.322 \cos N + 5''.693 \sin N$$

and from III

$$\delta_2 l = -0''.552 \cos N - 0''.483 \sin N$$

the sum being

$$\delta_2 l = +3''.770 \cos N + 5''.210 \sin N$$

A comparison of this result, reduced to 1850, with the results obtained by previous investigators follows.

	$6''.43 \sin \{221^\circ.17 + 0^\circ.202\,(t-1850.0)\}$
HANSEN	$6.43 \sin (220.72)$
NEWCOMB	$6.40 \sin (221.09)$
LEVERRIER	$6.21 \sin (225.23)$

The period of this term is nearly eighteen hundred years.

COMET *e* 1910 (*CERULLI*).

From the *Lick Observatory Bulletin*, No. 186, it appears that W. F. MEYER and SOPHIA H. LEVY, of the Berkeley Astronomical Department, have computed parabolic elements of Comet *e* 1910 from observations of Nov. 9, Nov. 11, and Nov. 13, as follows:

T = 1910, Nov. 19.487, Gr.M.T.

$$\left.\begin{aligned}\omega &= 200^\circ\ 17'.4\\ \Omega &= 212\ \ 57.8\\ i &= \ \ 18\ \ 17.1\end{aligned}\right\}1910.0$$

q = 2.19575

Induced by the resemblance of these elements to those of FAYE's Periodic Comet in 1903 (see *A.N.*, 3858), the before-mentioned computers deduced elliptic elements from the observations of Nov. 9, Nov. 11, and Nov. 13, with the following result:

T = 1910, Nov. 12.413, Gr.M.T.

$$\left.\begin{aligned}\omega &= 206^\circ\ 20'.4\\ \Omega &= 205\ \ 29.1\\ i &= \ \ 10\ \ 14.2\end{aligned}\right\}1910.0$$

e = 0.5459

μ = 512″.34

$\log a$ = 0.56030

Although there must be decided uncertainty in these elements, on account of the short interval of observation concerned, Mr. H. RAYMOND, of the Dudley Observatory, has computed the following Ephemeris, based on the elliptic elements. The unit of brightness is that of the Comet on Nov. 11.

1910 G.M.T.	R.A.	Decl.	log Δ	Brightness
	h m s	° ′		
Nov. 27.5	3 36 46	+4 49.1	9.8395	0.93
29.5	36 40	30.4		
Dec. 1.5	36 35	4 13.5	.8477	
3.5	36 36	3 58.7		
Dec. 5.5	3 36 41	+3 45.1	9.8575	
7.5	36 51	30.8		
9.5	37 7	19.1	.8687	
11.5	37 28	14.1		
Dec. 13.5	3 37 55	+3 9.4	9.8811	0.75
15.5	38 33	5.2		
17.5	39 16	2.1	.8946	
19.5	39 59	1.0		
Dec. 21.5	3 40 47	+3 0.7	9.9091	
23.5	41 46	2.6		
25.5	42 52	5.3	.9243	
27.5	44 2	9.9		
Dec. 29.5	3 45 20	+3 15.2	9.9402	
31.5	46 53	22.1	.9482	0.52

—ED.

EPHEMERIS OF HALLEY'S COMET,

BY F. E. SEAGRAVE.

12h G.M.T. 1911	R.A. h m s	Decl. ° ′	log r	log Δ	12h G.M.T. 1911	R.A. h m s	Decl. ° ′	log r	log Δ
Jan. 3	11 51 27	−18 18.1	0.5850	0.5571	Feb. 20	10 55 49	16 19.2	0.6378	0.5383
11	44 53	−18 26.1	0.5944	0.5501	28	44 44	−15 20.5	0.6158	0.5437
19	36 57	−18 23.9	0.6037	0.5441	Mar. 8	31 6	−14 14.3	0.6536	0.5521
27	27 51	18 10.8	0.6126	0.5393	16	24 15	13 3.7	0.6611	0.5633
Feb. 4	17 44	17 15.6	0.6213	0.5364	24	15 25	11 51.6	0.6681	0.5769
12	11 6 56	17 8.1	0.6297	0.5360	Apr. 1	10 7 49	10 40.7	0.6754	0.5924

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ON THE ACTION OF PLANETS UPON NEIGHBORING PARTICLES,

By PERCIVAL LOWELL.

1. In the planetary theory the perturbing function due to a planet of mass m' upon another of mass m is expressible as:

$$f\,m'\,R_{01} = f\,m'\left(\frac{1}{\Delta} - \frac{rs}{r'^2}\right)$$

where f is the attraction of gravitation of a unit mass at unit distance; r and r' the radii vectores of the two bodies; Δ the distance between them; and s the cosine of the angle which the radius-vector of the one makes with that of the other. The first term of the function,

$$f\,m'\frac{1}{\Delta} = f\,m'\left(r^2 + r'^2 - 2\,r\,r'\,s\right)^{-\frac{1}{2}} = f\,m'\,R_1$$

represents the direct pull of m' upon m, and may be expanded in a convergent series of cosines of multiples of $\theta' - \theta = \cos^{-1} s$, and this in turn in a series developed according to powers of $\eta^2 = \sin^2\frac{J}{2}$ where J is the mutual inclination of the two orbits.

Substituting for r and r' their values

$$r = a[1 - e\cos(nt + \epsilon) + e^2 - e^2\cos 2\,(nt + \epsilon)\text{ etc.}]$$
$$r' = a'[1 - e'\cos(n't + \epsilon') + e'^2 - e'^2\cos 2\,(n't + \epsilon)\text{ etc.}]$$

we find that this part of the perturbing function R_1 may be expressed*

$$f\,m'\,R_1 = f\,m'\sum N_1\,e^h\,e'^{h'}\,\eta^g\cos D$$

in which e and e' are the eccentricities of the orbits and

$$D = i\lambda + i'\,l' + k\,\omega + k'\,\varpi' - 2\,\gamma\,\tau'$$
$$\text{where } \lambda = l + \tau' - \tau$$
$$\omega = \varpi + \tau' - \tau$$
$$l = n\,t + \epsilon \qquad l' = n'\,t + \epsilon'$$

ϖ and ϖ', being the longitudes of the perihelia and τ' and τ the angles measured from the axis of x along the plane of reference to the nodes and thence along the orbits to their point of intersection. This series is convergent for all values of the mean motion so long as e and e' are less than 0.6627 which is the case for all the planets. N_1 is composed of a set of coefficients of which the typical form is $N_1 = V^i A^i + V^i_1 A^i_1 + V^i_2 A^i_2$. etc., where the V's are numbers and the A's are made up of A^i and of its derivatives multiplied by α or multiples of α.

A^i is the coefficient of $\cos\,i\varphi$ in the expansion of $(a^2 + a'^2 - 2aa'\cos\varphi)^{-\frac{1}{2}}$ in cosines of multiples of φ and is equal to

$$A^i = \frac{2}{a'}\cdot\frac{1\,.\,3\,.\,5\,\ldots\,(2i-1)}{2\,.\,4\,.\,6\,\ldots\,(2i)}\,\alpha^i\left[1 + \frac{1}{2}\cdot\frac{2i+1}{2i+2}\,\alpha^2 + \frac{1}{2}\cdot\frac{3}{4}\cdot\frac{2i+1\,.\,2i+3}{2i+2\,.\,2i+4}\,\alpha^4\right]\text{etc.}$$

$$\text{where } \alpha = \frac{a}{a'}\,.$$

These coefficients are introduced by the e's and e''s. Analogous ones B^i, C^i etc., are introduced by η^2, η^4, etc. from the expansions of $(a^2 + a'^2 - 2\,aa'\cos\varphi)^{-\frac{3}{2}}$ and $(a^2 + a'^2 - 2\,aa'\cos\varphi)^{-\frac{5}{2}}$ and so on.

These series are all convergent when $\alpha = \frac{a}{a'}$ is less than unity, a' being the semi-major axis of the outer planet, and a that of the inner one.

The second part of $R_{0,1}$ to wit $\frac{rs}{r'^2}$ (which is the relative change in position in m due to the action of m' upon the central body, the Sun) is made up of periodic terms combined in the same manner and having for coefficients in place of N_1 some numerical multiple of $\frac{a}{a'^2}$ which we may call N_2, all the coefficients, except A^1, A^{-1}, B^0, and their derivatives being zero.

We thus find that the complete perturbing function is

$$f\,m'\,R_{0,1} = f\,m'\sum N\,e^h\,e'^{h'}\,\eta^g\cos D$$

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* For the steps see LEVERRIER's exposition, *Annales de l'Observatoire de Paris, Mémoires*, Vol. 1, or TISSERAND's *Mécanique Céleste*, who has reproduced the proof largely verbatim.

writing N for $N_1 + N_2$ where $D = i\lambda + i'l' + k\omega + k'\varpi' - 2\gamma\tau'$.

If we take the plane of one orbit as the plane of reference we may simplify this expression, since in that case $\tau' - \tau = 0 \qquad \lambda = l \qquad \omega = \varpi$ and we get

$$f m' R_{0,1} = f m' \sum N e^{h} e'^{h'} \eta^{g} \cos D$$

$$\text{in which } D = i\,l + i'\,l' + k\,\varpi + k'\,\varpi' - 2\,\gamma\,\tau'$$
$$\text{and } l = nt + \epsilon \quad , \quad l' = n't + \epsilon'.$$

From this mode of origin of cos D, D being formed by combinations of $p[(n\,t + \epsilon) - (n'\,t + \epsilon')]$ (p having any value from 0 to ∞) multiples of $nt + \epsilon - \varpi$, and multiples of $n'\,t + \epsilon' - \varpi'$, i and i' must always be integers, and in the formula all values of them must be taken from $-\infty$ to $+\infty$, including 0.

All the terms in $R_{0,1}$ are expressible by cosines of combinations of multiples of l and l' because in the expansions cosines are always found multiplying cosines and sines, sines.

In consequence of the way in which D is formed

$$h = |k| + \text{an even number}$$
$$h' = |k'| + \text{an even number}$$
$$g = 2\gamma + \text{an even number}$$

in which $|k|$ and $|k'|$ denote the absolute values of k and k'.

This may perhaps be shown most simply as follows: D is formed by the combination of arguments of the series $k(n - n')\,t$ with those derived from the expansions of r and r' multiplied into one another. Consider a term in r^2,

$$e^{q} \cos q\,(n\,t + \epsilon - \omega).$$

This term could only have arisen from two terms, $l\,(n\,t + \epsilon - \omega)$ and $m\,(nt + \epsilon - \omega)$ in which $l + m = q$; in which case the coefficient in e would be

$$e^{l}\,e^{m} = e^{l+m} = e^{q}$$

or from two terms $r\,(nt + \epsilon - \omega)$, $s\,(nt + \epsilon - \omega)$ in which $r - s = q$ in which event the coefficient would be $e^{r}\,e^{s} = e^{r+s} = e^{q+2s}$.

The like reasoning applies to all the powers and products thus formed.

2. By the principle of the variation of elements the variation in the major axis consequent upon the perturbing force may be found by equating the first derivative of the undisturbed motion to that of the disturbed one. In the undisturbed motion

$$-\frac{\mu}{a} = \left(\frac{d\,r}{d\,t}\right)^2 + r^2\left(\frac{d\,\theta}{d\,t}\right)^2 - \frac{2\mu}{r};$$

in the disturbed

$$C + 2n\,m' \int_t \frac{d\,R_{0,1}}{d\,\epsilon} = \left(\frac{d\,r}{d\,t}\right)^2 + r^2\left(\frac{d\,\theta}{d\,t}\right)^2 - \frac{2\mu}{r}$$

to terms of the first order in the masses.

Whence

$$-\frac{\mu}{a} = C + 2n\,m' \int_t \frac{d\,R_{0,1}}{d\,\epsilon}$$

differentiating

$$\frac{d\,a}{d\,t} = \frac{2n\,m'\,a^2}{\mu} \cdot \frac{d\,R_{0,1}}{d\,\epsilon} = \frac{2\,m'}{n\,a} \cdot \frac{d\,R_{0,1}}{d\,\epsilon}$$

since to terms of the first order in the masses $\mu = n^2\,a^3$.

Whence

$$\frac{d\,a}{d\,t} = -\frac{2\,m'}{n\,a} \sum N e^{h}\,e'^{h'}\,\eta^{g}\,i \sin D$$

and integrating

$$\delta\,a = \frac{2\,m'}{n\,a} \sum N e^{h}\,e'^{h'}\,\frac{\eta^{g}\,i \cos D}{i\,n - i'\,n'}\,.$$

To terms of this order in the general case $\frac{d\,a}{d\,t}$ is made up of periodic terms only, since for $i = 0$, $i' = 0$, from which arise the secular terms in the other elements,

$$D = k\,\varpi + k'\,\varpi' - 2\,\gamma\,\tau'$$

$i\,(nt + \epsilon)$ and $i'\,(n't + \epsilon')$ going out.

Consequently $\frac{d\,R_{0,1}}{d\,\epsilon} = 0$ and $\frac{d\,a}{d\,t} = 0$ and $\delta a =$ constant.

Or in other words there is a permanent alteration made by the perturbation in the major axis of the perturbed body resulting in the major axis of observation, but no secular change occasioned in it.

In the development of the perturbing function to the second order with regard to the masses, Poisson proved that terms enter of the form $t \cos D$ and $t \sin D$ in the perturbation of the major axis and later Haretu showed that in the extension to the third order in the masses secular terms arise.

3. There is, however, one set of circumstances in which secular terms might arise in the perturbation of the major axis in the development of the perturbing function to the first order, to wit: if $i\,n - i'\,n' = 0$ while $i \neq 0$, $i' \neq 0$.

In such a case D would degrade to

$$D = i\,\epsilon - i'\,\epsilon' + k\,\varpi + k'\,\varpi' - 2\,\gamma\,\tau'$$

giving in $\frac{d\,a}{d\,t}$ the term

$$-\frac{2\,m'}{n\,a\,a'}N\,e^h\,e'^{h'}\,\eta^g\,i\,.\,\sin\,(i\epsilon-i'\epsilon'+k\varpi+k'\varpi'-2\,\gamma\tau')$$

whence for this term

$$\delta\,a=-\frac{2\,m'}{n\,a\,a'}N\,e^h e'^{h'}\eta^g\,i\,t\,.\,\sin\,(i\,\epsilon-i'\,\epsilon'+k\varpi+k'\varpi'-2\gamma\,\tau')$$

a secular term increasing with the time.

The condition $i\,n-i'\,n'=0$ with $i\neq 0$, $i'\neq 0$ denotes that i times the revolution of the one body equals i' times that of the other, which means that the periods of the two are commensurable. In this case there is indefinite increase in the major axis, or in other words one planet will not suffer another to travel in an orbit whose period is commensurate with its own. No known instance of commensurability of period occurs among the planets so that the situation does not present itself in the actual motions of the system.

II. 4. It is different when we consider that system's past and its possible mode of evolution. The effect of one body upon the major axis of another revolving about the Sun in a period commensurate with its own is expressed, as we have seen, by a set of terms in which $i\,n-i'n'=0$ when $i\neq 0$ and $i'\neq 0$, together with others in which $i\,n-i'\,n'$ is not zero. The second set is periodic and does not here concern us. Considering the first set we have

$$D=i\,\epsilon-i'\epsilon'+k\varpi+k'\varpi'-2\,\gamma\tau'$$

$$\frac{d\,a}{d\,t}=-\frac{2f\,m'}{n\,a}\sum N e^h\,e'^{h'}\,\eta^g\,i\,\sin\,D$$

$$\text{and }\delta a=-\frac{2f\,m'}{n\,a}\sum N\,e^h\,e'^{h'}\,\eta^g\,i\,t\,\sin\,D$$

f being the constant of gravitation.

All integral values of i will be included from $-\infty$ to $+\infty$. The several terms will have coefficients in e depending on the numerical value of $i-i'$, and similarly in e' for $i'-i$. If $i-i'=0$ there will be two terms independent of e and e', one formed by $i-i'=0$ and one by $i'-i=0$. In this case the major axis of the two bodies would be the same to begin with but neither would suffer the other to remain so. An oscillation in the lengths of the major axes would result, concomitant with a change in the periodic time, until the two bodies met and coalesced.

Only in one configuration would this result be affected and then rather in a theoretic than in a practical manner, to wit: in the case of LAGRANGE's equiangular solution. If a particle arrived at the proper position with the proper velocity it might move as he showed, provided nothing disturbed it. But the chance of such arrival is in the first place small and after arrival perturbations of other bodies would tend to destroy the equilibrium. Except, therefore, in exceptional instances, such configuration in permanency could not arise.

Consider now the next most important case: when $i-i'=\pm 1$. Here present themselves an infinity of terms: $2-1$, $3-2$, $4-3$, etc. Each corresponds to a body having a definite major axis which approaches more and more closely to that of m' as the values of i and i' increase. All of these terms have e in the principal part of their coefficients. Their negatives similarly contain e'. It is evident that the orbits of such bodies, the periods of which are commensurate with that of m', cluster closer together as they approach m'. If represented graphically they would resemble flutings proceeding from the orbit of m' and widening according to a regular law of extension. Such flutings would also spread outward from m' as well as inward, though the actual spacing would be somewhat greater without than within.

We now proceed to consider the relative importance of the terms of this series according as $i=1,2,3$, etc. In this case

$$N=\tfrac{1}{2}\,[-2i\,A^i-A^i_1]\quad\text{for the term in } e$$

$$\text{and}\quad N=\tfrac{1}{2}\,[2i+1\,.\,A^i+A^i_1],\ \text{for those in } e'$$

$$\text{where } A^i_1=\alpha\frac{d\,A^i}{d\,\alpha}\,.$$

Now

$$A^i=\frac{2}{a'}\cdot\frac{1\,.\,2\,.\,3\,\ldots\ldots(2\,i-1)}{2\,.\,4\,.\,6\,\ldots\ldots(2\,i)}\alpha^i\left[1+\frac{1}{2}\cdot\frac{2\,i+1}{2\,i+2}\alpha^2\right.$$

$$\left.+\frac{1}{2}\cdot\frac{3}{4}\cdot\frac{2\,i+1\,.\,2\,i+3}{2\,i+2\,.\,2\,i+4}\alpha^4+\right]\text{etc.,}$$

$$\text{where}\qquad \alpha=\frac{a}{a'}\,.$$

From which it appears that N increases in numerical value as $\alpha=\frac{a}{a'}$ approaches unity. But as α approaches unity both i and i' increase, $i-i'$ still being 1. N therefore for these orbits increases with i and i'.

It will be well to point out here a distinction in the value of N according to whether we are considering a set of periodic terms of the form $N\cos\,(int-i'n't)$ applying to one body of a certain major axis or as here to several different bodies revolving in different orbits. In the first case the coefficient N decreases as i increases. In the second case calculation will show that it increases because of the increase in α, which more than nullifies the serial decrease in A^1, A^2, A^3, etc. when α remains the same.

Not only is N increased with i in the expression of $R_{0,1}$ for the different orbits and consequently in that of δa, but, since $\frac{d\,R_{0,1}}{d\,\epsilon}$ enters into the value of $\frac{d\,a}{d\,t}$, in the integration to δa, the coefficient is multiplied by i. The term in question, therefore increases with i, both on the score of N and on that of i itself. The remaining part of the coefficient outside of e, to wit:

$$\frac{2\,m'}{n\,a}$$

also increases since $$n = \frac{\mu^{\frac{1}{2}}}{a^{\frac{3}{2}}}\,,$$

whence $$\frac{2\,m'}{n\,a} = \frac{2\,m'a^{\frac{1}{2}}}{\mu^{\frac{1}{2}}}\,,$$

which, since m' and μ are constant, increases with a. The whole coefficient therefore increases as i increases. We see, then, that the perturbing effect of m' upon bodies revolving inside or outside its own orbit increases as those orbits approach its own, becoming, at equality, infinitely large.

Similar reasoning applies to the series in e^2, e'^2 etc. These series have a smaller and smaller effect in proportion as they are multiplied by higher and higher powers of e and e'.

But this is not all. Not only are the commensurable orbits clustered closer together in the neighborhood of the orbit of the disturbing planet and the secular perturbation of the major axis there greatly increased, but the periodic disturbances are themselves augmented for points between. For consider the periodic term:

$$\delta a = \frac{2\,f\,m'}{n\,a}\,N\,e\,\frac{i}{i\,n - i'\,n'}\cos D\,,$$

in which $i = 100$, $i' = 99$, n having the value $\frac{1}{99}$ and n' say $\frac{1}{99.5}$ approx. for the point farthest removed from the commensurate orbits. As regards the mid point between $\frac{n'}{n} = \frac{2}{1}$ and $\frac{n'}{n} = \frac{3}{2}$, the coefficient of the term in question is much greater in the former case — both because $\frac{N\,i}{n\,a}$ is greater and because $i\,n - i'\,n'$ is less.

The result is that when the inner body in a near commensurable orbit has had its major axis lengthened and in consequence moves outward it falls into a position of great periodic disturbance which causes it to move still further out till it reaches the next commensurable orbit, and so the process goes on crescendo until the two bodies meet and combine. This cannot happen farther away from m', where the commensurable orbits are more spaced and where the periodic effect between them is too small.

This investigation, then, shows that the effect of a planet in consequence of its perturbation on the major axes of bodies revolving in somewhat the same periods is to gather all these bodies in time into itself and thus sweep space in its vicinity. We thus find from the analytic discussion a *modus operandi* by which originally discrete particles, or a ring of such, could have been gathered into the planets we at present observe.

Boston, 1910 *Nov.* 6.

ELEMENTS AND EPHEMERIS OF PLANET 1909 *JB*,

By ALFRED DAVIS.

The following elements were computed from observations on November 7, December 9, 1909; and January 8, 1910. The first and last are photographic observations furnished by Rev. JOEL METCALF, the other is by Prof. E. YOWELL.

ELEMENTS.

1909 Nov. 7.5, Gr.M.T.

$$\begin{aligned} M &= 47^\circ\ 14'\ 8'' \\ \left.\begin{aligned} \omega &= 77\ \ 45\ \ 11 \\ i &= 13\ \ 55\ \ 42 \\ \Omega &= 275\ \ 38\ \ 14 \end{aligned}\right\}&\ 1909.0 \\ q &= 8\ \ 56\ \ 35 \\ \mu &= 877''.30 \qquad \log a = 0.40457 \end{aligned}$$

RESIDUALS (O − C).

		$\Delta\alpha$	$\Delta\delta$			$\Delta\alpha$	$\Delta\delta$
		s	″			s	″
1909 Nov.	7	−0.2	−0.5	Dec.	1	+0.2	−1.6
	30	+0.1	−2.3	1910	9	0.1	+0.6
				Jan.	8	−0.1	+0.6

HELIOCENTRIC COORDINATES 1909.0.

$$\begin{aligned} x &= [9.98717]\,r \sin (v + \ \ 83^\circ\ 35'\ 19'') \\ y &= [9.96045]\,r \sin (v + 347\ \ 15\ \ 27) \\ z &= [9.67502]\,r \sin (v + \ \ 20\ \ 56\ \ \ 2) \end{aligned}$$

EPHEMERIS 12h Gr.M.T.

1911	α (1911.0)	δ (1911.0)	log Δ	Ab. T.
	h m s	° ′ ″		m s
Jan. 29	10 48 00	−10 36 13	0.32158	17 26
Feb. 2	45 18	45 6	31525	11
6	42 19	50 15	30961	16 58
10	39 4	52 9	30472	48
14	35 36	50 35	30066	37
18	31 58	45 36	29749	30
22	28 14	37 18	29526	25
26	24 28	25 39	29402	22
Mar. 2	20 42	11 28	29378	21
6	17 1	54 32	14956	23
10	13 29	9 35 26	29630	27
14	10 9	11 35	29900	33
18	7 4	8 52 24	30261	41
22	4 16	29 19	30708	52
26	1 17	5 14	31231	17 4
30	9 59 40	7 42 5	31838	18
Apr. 3	9 57 55	− 7 18 45	0.32483	17 34

Opposition in R.A. March 2.
Magnitude at opposition about 10th

Observatory University of Minnesota, Minneapolis, Minn., 1910 *Dec.* 8.

OBSERVATIONS OF THE SATELLITES OF *SATURN* AT THE OPPOSITION OF 1908,

MADE WITH THE 26-INCH EQUATORIAL AT THE U. S. NAVAL OBSERVATORY,

By J. C. HAMMOND.

[Communicated by Commodore T. E. De Witt Veeder, U. S. Navy, Superintendent.]

Mimas — Tethys.

1908	Wash. M.T.	p	Wash. M.T.	s	Comp.	Seeing	1908	Wash. M.T.	p	Wash. M.T.	s	Comp.	Seeing
	h m s	°	h m s	″				h m s	°	h m s	″		
Aug. 29	11 41 48	272.348	11 42 10	74.46	4, 4	g	Sept. 8	11 6 50	98.116	11 7 8	49.58	4, 4	g
30	11 36 1	87.795	11 36 14	15.17	4, 4	g	29	12 34 13	91.525	12 34 29	19.22	4, 4	g
Sept. 6	11 52 48	102.252	11 53 5	43.22	4, 4	f	30	10 34 43	276.055	10 35 1	74.54	4, 6	g

Mimas — Rhea.

1908	Wash. M.T.	p	Wash. M.T.	s	Comp.	Seeing	1908	Wash. M.T.	p	Wash. M.T.	s	Comp.	Seeing
Aug. 29	11 48 29	281.119	11 48 33	66.53	4, 4	g	Sept. 8	11 12 59	272.981	11 13 2	60.00	4, 4	g
30	11 42 54	270.886	11 42 58	107.91	4, 4	g	29	12 42 14	357.396	12 42 4	9.84	6, 4	g
Sept. 6	11 44 54	90.396	11 44 21	101.69	4, 4	f	30	10 51 31	277.321	10 51 42	97.81	4, 6	g

Enceladus — Tethys.

1908	Wash. M.T.	p	Wash. M.T.	s	Comp.	Seeing	1908	Wash. M.T.	p	Wash. M.T.	s	Comp.	Seeing
Aug. 29	11 29 14	269.923	11 29 33	74.79	8, 8	g	Sept. 30	9 55 20	272.984	9 55 36	12.50	8, 8	g
30	11 51 28	72.352	11 51 27	19.17	8, 8	g	30	11 11 9	272.328	11 11 17	10.28	8, 8	g
31	12 28 56	245.282	12 28 47	2.58	8, 8	f	Oct. 3	9 57 15	90.066	9 57 27	74.14	8, 8	f
Sept. 1	12 45 30	91.707	12 45 47	44.99	8, 8	g	5	9 37 40	35.470	9 37 34	1.95	8, 8	e
6	12 2 10	260.004	12 1 45	24.48	8, 8	f	7	9 52 22	88.067	9 52 29	59.67	8, 8	g
8	11 24 5	101.220	11 24 14	59.14	8, 8	g	14	9 41 58	94.617	9 42 9	60.38	8, 8	g
12	11 33 56	98.419	11 33 42	66.60	8, 8	e							

Tethys — Dione.

1908	Wash. M.T.	p	Wash. M.T.	s	Comp.	Seeing	1908	Wash. M.T.	p	Wash. M.T.	s	Comp.	Seeing
Aug. 29	12 10 25	85.577	12 10 42	67.43	8, 8	g	Sept. 23	11 8 33	293.483	11 8 38	35.76	8, 9	g
30	12 3 32	270.093	12 3 44	97.87	8, 8	g	29	11 28 24	274.089	11 28 26	108.83	8, 8	g
31	12 40 8	92.661	12 40 13	86.14	8, 8	g	30	10 25 49	97.735	10 25 46	86.46	8, 10	g
Sept. 1	12 23 51	276.484	12 23 32	40.82	8, 8	g	Oct. 3	10 9 6	107.216	10 9 10	14.65	8, 8	f
3	11 40 31	100.085	11 40 30	46.12	8, 8	g	4	10 3 24	65.164	10 3 23	17.87	8, 8	f
6	12 12 48	73.465	12 12 47	33.44	8, 8	f	5	9 50 0	265.432	9 49 47	64.03	8, 8	e
8	11 35 3	104.449	11 34 39	3.32	8, 8	g	7	10 6 12	272.206	10 6 18	72.56	8, 8	e
12	11 24 59	281.481	11 25 9	63.71	8, 8	e	14	10 13 23	86.104	10 13 12	22.99	8, 8	f

Tethys — Rhea.

1908	Wash. M.T.	p	Wash. M.T.	s	Comp.	Seeing	1908	Wash. M.T.	p	Wash. M.T.	s	Comp.	Seeing
Aug. 29	12 30 46	20.835	12 30 58	11.61	8, 8	g	Sept. 12	11 15 4	276.523	11 15 7	120.50	8, 8	e
30	12 14 59	270.218	12 15 4	120.54	8, 8	e	23	11 20 1	94.857	11 19 59	40.89	8, 8	g
31	12 19 52	101.101	12 20 9	44.30	8, 8	f	25	10 31 17	290.835	10 31 11	47.37	8, 8	e
Sept. 1	12 56 46	98.050	12 56 39	61.63	8, 8	e	29	11 18 0	312.332	11 18 12	16.13	8, 8	g
3	11 48 52	272.000	11 48 56	90.53	8, 8	g	30	10 5 52	283.093	10 5 56	20.77	8, 8	g
6	12 23 2	80.074	12 23 1	54.88	8, 8	f	Oct. 3	10 21 36	90.551	10 21 9	35.84	8, 8	f
8	11 44 58	274.791	11 44 52	111.19	8, 8	g	4	9 52 31	70.784	9 52 41	28.00	8, 8	f
9	9 36 0	135.969	9 36 31	23.09	8, 8	f	5	9 59 24	271.629	9 59 31	120.94	8, 8	e

Dione — Rhea.

1908	Wash. M.T.	p	Wash. M.T.	s	Comp.	Seeing	1908	Wash. M.T.	p	Wash. M.T.	s	Comp.	Seeing
Aug. 29	11 58 33	275.056	11 58 45	61.34	8, 8	g	Sept. 22	11 0 47	271.116	11 0 51	115.83	8, 8	e
30	12 26 47	271.451	12 26 47	23.77	8, 8	e	29	11 38 27	88.059	11 38 29	95.03	8, 8	g
31	12 48 12	264.131	12 48 33	42.46	8, 8	g	30	10 15 5	278.950	10 15 5	106.51	8, 8	g
Sept. 1	12 35 15	97.377	12 35 10	100.21	8, 8	g	Oct. 3	10 33 25	78.140	10 33 42	20.75	8, 8	f
3	11 58 53	274.641	11 58 57	137.39	8, 8	g	4	9 41 7	76.887	9 41 16	8.69	8, 8	f
6	12 32 50	90.293	12 32 57	23.88	8, 8	f	5	10 8 53	278.506	10 8 50	60.26	8, 8	e
8	11 53 37	275.061	11 53 40	115.00	8, 8	g	7	10 29 56	95.732	10 30 9	135.28	8, 8	e
12	11 44 17	270.655	11 44 23	56.96	8, 8	e	14	9 51 42	273.967	9 51 48	145.34	8, 8	g

Rhea — Titan.

1908 Wash. M.T.		p	Wash. M.T.	s	Comp.	Seeing
	h m s	°	h m s	″		
Aug.	29 12 40 9	99.730	12 44 30	200.85	4 , 8	g
	30 12 38 9	93.595	12 38 14	273.76	8 , 8	e
	31 12 58 50	89.014	12 58 50	187.94	8 , 8	g
Sept.	1 13 9 30	85.875	13 9 23	94.62	8 , 8	e
	3 12 9 51	85.753	12 10 2	145.85	8 , 8	g
	8 12 8 21	272.899	12 8 37	108.00	8 , 8	g
	12 11 4 41	107.549	11 4 50	108.69	8 , 8	e
	22 10 48 33	285.867	10 48 30	91.83	8 , 8	e

1908 Wash. M.T.		p	Wash. M.T.	s	Comp.	Seeing
	h m s	°	h m s	″		
Sept.	29 11 19 57	110.364	11 50 3	85.99	8 , 8	g
	30 10 43 18	97.260	10 43 18	237.45	8 , 8	g
Oct.	3 10 45 39	88.982	10 45 47	98.54	8 , 8	p
	5 10 20 20	85.471	10 20 27	145.73	8 , 8	e
	7 10 18 14	279.743	10 18 29	175.56	8 , 8	e
	14 10 2 2	101.451	10 2 5	130.99	8 , 8	g
	17 10 0 11	97.094	10 0 30	153.79	8 , 8	g

Titan — Hyperion.

1908 Wash. M.T.		p	Wash. M.T.	s	Comp.	Seeing
Aug.	29 13 23 52	90.672	13 23 22	89.37	4 , 4	g
	30 13 1 54	91.268	13 2 49	70.92	4 , 4	e
	31 13 22 15	92.858	13 22 15	63.14	4 . 4	g
Sept.	1 13 30 54	94.580	13 31 21	67.43	1 , 5	e
	3 12 38 19	94.077	12 38 37	98.14	6 , 6	g
	29 12 24 26	279.928	12 24 50	270.57	4 . 7	g

1908 Wash. M.T.		p	Wash. M.T.	s	Comp.	Seeing
Sept.	30 11 40 0	276.315	11 40 10	363.21	4 . 6	g
Oct.	2 10 33 4	271.919	10 33 18	406.06	8 .10	p
	3 11 19 23	269.409	11 19 57	341.57	8 ,10	p
	4 10 43 17	265.200	10 44 18	243.11	8 ,10	f
	14 10 28 51	84.589	10 29 7	189.79	6 ,6	f
	20 9 53 10	273.144	9 53 19	256.86	8 , 8	f

Titan — Iapetus.

1908 Wash. M.T.		p	Wash. M.T.	s	Comp.	Seeing
Aug.	29 13 11 38	149.871	13 11 42	49.42	8 , 8	g
	30 12 50 6	139.186	12 50 7	50.41	8 , 8	e
	31 13 9 19	117.598	13 9 27	76.76	8 , 8	g
Sept.	1 13 19 17	104.462	13 19 17	134.37	8 , 8	e
	3 12 24 25	94.866	12 24 51	314.02	8 , 8	g
	29 12 4 32	25.207	12 4 39	174.39	8 , 8	g
	30 11 1 42	352.411	11 1 49	151.46	8 , 8	g

1908 Wash. M.T.		p	Wash. M.T.	s	Comp.	Seeing
Oct.	2 10 51 25	310.938	10 51 26	189.69	8 , 8	p
	3 10 58 58	303.539	10 59 19	195.54	8 , 9	p
	4 10 25 6	300.193	10 25 20	182.42	8 , 9	f
	5 10 32 10	299.594	10 32 22	153.62	8 , 8	e
	7 9 41 22	305.937	9 41 27	86.86	8 , 8	g

In the column of "Seeing" p is poor; f is fair; g is good; and e is excellent.

Titan — Iapetus

1908 Wash. M.T.*		Δα	Δδ	Comp.	Seeing
	h m s	m s	′ ″		
Sept.	8 12 28 12	+0 47.258	+0 41.80	15 , 5	g
	12 12 0 38	−0 35.680	+1 59.04	15 . 5	e
Sept	22 11 30 4	+0 39.630	+2 6.70	11 . 5	e
Oct.	17 10 22 13	−0 46.598	−0 20.62	18 . 6	g
	26 8 43 46	−0 24.037	−1 59.78	18 , 6	f

* The time of *Titan* is given.

OBSERVATIONS OF MINOR PLANETS,

MADE WITH THE 26-INCH AND THE 12-INCH EQUATORIALS AT THE U.S. NAVAL OBSERVATORY.

[Communicated by Commodore T. E. De Witt Veeder, U.S.N. Superintendent.]

1908 Wash. M.T.		*	Comp.	Δα	Δδ	App. α	App. δ	log pΔ		Red. to App. Pl.	
				[1907 *YD*]							
	h m s			m s	′ ″	h m s	° ′ ″			s	″
June	27 11 31 59	1	30 , 6	−0 43.39	+5 13.5	20 39 33.87	−19 17 25.9	8.540	0.872	+1.70	+7.6*
July	1 11 14 3	2	21 , 5	−0 33.68	−2 9.9	20 37 4.23	−19 20 19.6	8.518	0.872	+1.82	+7.8*
	30 12 29 2	3	25 , 5	−1 50.98	−0 7.6	20 13 20.35	−19 56 9.2	9.018	0.872	+2.31	+7.8*
Aug.	1 12 29 35	4	25 , 5	1 39.01	+0 31.0	20 11 39.09	19 58 17.1	9.097	0.871	+2.31	+7.7*
	1 12 11 15	5	25 , 5	0 51.52	+5 50.4	20 11 38.55	19 58 17.0	9.193	0.868	+2.31	+7.6*
	3 11 7 12	6	25 , 5	+2 33.17	+2 2.2	20 10 2.86	−20 0 12.1	8.458*n*	0.876	+2.31	+7.2*
	3 11 10 22	7	25 , 5	+1 56.82	+9 31.0	20 10 1.80	20 0 13.1	8.622	0.875	+2.31	+7.4*
				(40) *Harmonia.*							
July	29 11 58 6	8	25 , 5	+1 0.68	+0 37.9	21 4 20.50	21 33 0.0	8.892*n*	0.881	+2.27	+10.1*
Aug.	3 12 36 15	9	20 , 1	−3 59.90	−3 9.1	20 59 22.07	−22 6 14.0	8.754	0.884	+2.32	+10.0*
	3 12 55 36	10	25 , 5	−0 24.87	+0 15.8	20 59 21.11	−22 6 19.1	8.991	0.882	+2.32	+9.8*

Wash. M.T. 1909-10	*	Comp.	Δα	Δδ	App. α	App. δ	log pΔ		Red. to App. Pl.	
					(241) *Germania.*					
1909 h m s			m s	′ ″	h m s	° ′ ″			s	″
Apr. 10 11 50 26	11	25 , 5	+0 41.39	− 1 46.9	13 50 48.75	−18 54 37.0	8.977*n*	0.868	+1.03	6.2*
11 10 51 14	12	25 , 5	1 24.59	− 3 22.8	13 50 5.27	−18 50 41.9	9.310*n*	0.858	+1.05	− 6.3*
22 11 3 56	13	25 , 5	−1 24.96	+ 7 12.1	13 41 34.32	−18 0 2.5	8.868*n*	0.865	+1.14	− 7.4*
23 10 57 42	14	25 , 5	−1 40.79	− 3 36.3	13 40 48.22	−17 55 1.0	8.887*n*	0.864	+1.14	− 7.5*
26 12 6 38	15	25 , 5	−1 43.09	− 1 13.7	13 38 28.67	−17 39 20.8	8.984	0.862	+1.17	− 7.9*
1910 July 24 12 8 54	16	25 , 5	−2 24.11	− 4 23.6	19 29 28.51	−18 30 16.0	8.997	0.866	+2.52	+ 1.0†
25 10 12 39	16	25 , 5	−3 10.47	− 4 39.2	19 28 42.15	−18 30 31.6	8.855*n*	0.867	+2.52	+ 1.0†
					(288) *Glauke.*					
1909 June 15 12 7 53	17	25 , 5	+0 10.26	+ 1 52.7	17 29 9.14	−18 41 1.9	8.472	0.869	+1.84	− 3.0*
21 11 3 57	18	25 , 5	+2 0.48	+ 6 5.5	17 23 44.10	−18 48 46.6	8.645*n*	0.870	+1.93	− 3.3*
24 11 58 43	19	25 , 5	+1 33.12	− 6 35.1	17 21 6.73	−18 53 9.4	8.906	0.869	+1.94	− 3.5*
29 11 29 55	20	30 , 6	−0 4.85	− 0 5.4	17 17 6.18	−19 1 1.2	8.958	0.869	+1.95	− 3.4*
July 6 10 28 23	21	25 , 5	+1 17.01	+ 4 59.1	17 12 18.94	−19 13 18.3	8.468	0.872	+1.99	− 3.8*
					(19) *Fortuna.*					
July 24 11 7 49	22	25 , 5	+0 16.67	− 4 36.0	19 51 44.95	−18 14 19.6	8.865*n*	0.866	+2.30	+ 4.1‡
Aug. 7 9 29 52	23	25 , 5	−0 52.53	− 6 35.2	19 38 39.88	−18 51 9.7	9.130*n*	0.865	+2.37	+ 3.5‡
					(16) *Psyche.*					
July 28 11 52 34	24	30 , 6	+2 56.25	+ 4 58.4	20 22 19.84	−17 13 13.4	8.011*n*	0.862	+2.32	− 5.8*
					(95) *Arethusa.*					
Aug. 7 10 42 2	25	30 , 6	−1 44.97	+ 6 20.7	20 7 54.06	− 2 19 25.7	8.638*n*	0.761	+2.21	+ 6.4‡
1910 Nov. 22 10 23 10	26	25 , 5	−1 46.70	− 2 46.7	3 47 1.51	+21 38 11.8	9.220*n*	0.436	+3.54	+16.1‡
26 9 25 38	27	30 , 6	−0 6.93	+ 1 44.8	3 43 41.44	+21 5 59.3	9.381*n*	0.474	+3.54	+16.5‡
30 9 15 16	28	29 , 6	−0 53.55	− 2 34.3	3 40 27.01	+20 33 35.0	9.349*n*	0.478	+3.55	+16.6‡
					(57) *Mnemosyne.*					
1909 Aug. 10 11 33 1	29	24 , 5	+2 29.82	− 4 51.7	22 6 45.11	+ 6 48 31.9	9.185*n*	0.671	+2.16	+ 9.4*
10 11 58 26	30	25 , 5	−1 26.46	+ 7 59.2	22 6 44.35	+ 6 48 26.6	9.017*n*	0.669	+2.15	+ 9.5*
21 10 45 20	31	25 , 5	+3 10.71	− 3 59.9	21 59 25.45	+ 5 49 41.1	9.168*n*	0.682	+2.26	+10.9*
					(13) *Egeria.*					
1910 Apr. 2 10 20 50	32	25 , 5	−0 51.05	− 5 58.4	12 33 48.73	+14 43 14.9	9.260*n*	0.569	+1.22	7.0†
9 13 48 57	33	15 , 3	−2 21.34	− 0 8.7	12 26 20.72	+14 29 31.6	9.466	0.600	+1.23	− 6.1†
14 13 0 55	34	25 , 5	−2 59.67	−13 47.4	12 21 34.32	+14 12 59.5	9.402	0.592	+1.24	− 5.6†
					(28) *Bellona.*					
Apr. 30 13 56 34	35	20 , 4	+2 0.74	− 0 42.6	15 5 23.44	− 2 28 38.0	9.217	0.761	+1.34	− 9.8†
May 4 13 43 7	36	25 , 5	−0 49.89	+ 2 54.1	15 2 5.21	− 2 10 49.7	9.244	0.758	+1.38	− 9.8†

Observers, * = M. Frederickson; ‡ = J. B. Eppes; † = H. E. Burton.
Asteroids [1907 *YD*], (241) *Germania*, and (288) *Glauke* were observed on the 26-inch equatorial, the others on the 12-inch.

Mean Places of Comparison-Stars for the beginning of the Year.

*	α	δ	Authority	*	α	δ	Authority
	h m s	° ′ ″			h m s	° ′ ″	
1	20 40 15.56	−19 23 17.0	A.G. Algiers Zones	19	17 19 31.67	−18 46 30.8	A.G. Algiers Zones
2	20 36 28.73	−19 23 7.3	" " "	20	17 17 9.08	−19 0 52.4	" " "
3	20 15 9.02	−19 56 9.4	" " "	21	17 10 59.94	−19 18 13.6	" " "
4	20 13 15.79	−19 58 55.8	" " "	22	19 51 25.98	−18 9 47.7	" " "
5	20 12 27.76	−20 4 15.0	" " "	23	19 39 30.04	−18 44 38.0	" " "
6	20 7 27.08	−20 2 21.5	" " "	24	20 19 21.27	−17 18 17.6	A.G. Washington 7675
7	20 8 2.67	−20 9 51.8	" " "	25	20 9 36.82	− 2 25 52.8	A.G. Straszburg 6964
8	21 3 17.55	−21 33 48.0	" " "	26	3 48 44.67	+21 40 42.4	A.G. Berlin B 1242
9	21 3 19.65	−22 3 14.9	" " "	27	3 43 44.83	+21 3 58.0	" " " 1194
10	20 59 43.69	−22 7 14.7	" " "	28	3 41 17.01	+20 35 52.7	" " " 1156
11	13 50 6.33	−18 52 43.9	" " "	29	22 4 13.13	+ 6 53 14.2	A.G. Leipzig II 11121
12	13 51 28.81	−18 47 12.8	" " "	30	22 8 8.66	+ 6 40 17.9	" " " 11158
13	13 42 58.14	−18 7 7.2	A.G. Washington 5190	31	21 56 12.48	+ 5 53 30.1	" " " 11064
14	13 42 27.87	−17 51 17.2	" " 5186	32	12 34 38.56	+14 49 20.3	$\frac{1}{2}$ {A.G. Leipzig I, 4640 + A.G. Berlin A, 4720}
15	13 40 10.59	−17 37 59.2	" " 5175	33	12 28 40.83	+14 29 46.4	A.G. Leipzig I 4608
16	19 31 50.10	−18 25 53.4	Hedrick's Zod. Cat. 1305	34	12 24 32.75	+14 26 52.5	" " " 4593
17	17 28 57.04	−18 42 51.6	A.G. Algiers Zones	35	15 3 21.36	− 2 27 45.6	A.G. Straszburg 5299
18	17 21 41.69	−18 54 48.8	" " "	36	15 2 53.70	− 2 13 34.0	A.G. Nicolajew 3868

OBSERVATIONS OF HALLEY'S COMET,

MADE WITH THE 16-INCH EQUATORIAL AT THE CINCINNATI OBSERVATORY,

By J. G. PORTER and EVERETT I. YOWELL.

1910 Cin. M.T.		*	Comp.	Δα	Δδ	App. α	App. δ	log pΔ		Red. to App. Pl.	
	h m s			m s	′ ″	h m s	° ′ ″			s	″
Jan. 3	7 28 24	1	10 , 6	−0 57.35	−12 35.7	2 9 22.44	+11 9 13.1	8.315	0.612	−0.50	−1.1*
9	9 41 7	3	12 , 8	+1 12.70	+ 7 24.5	1 50 24.36	+10 18 12.4	9.526	0.662	−0.66	−2.3†
10	7 49 11	3	9 , 6	−1 23.97	+ 0 17.9	1 47 47.69	+10 11 5.8	9.201	0.633	−0.66	−2.3†
31	7 13 2	4	10 , 6	+1 59.77	− 0 19.8	1 3 58.81	+ 8 22 44.4	9.495	0.675	−1.19	−5.4*
Feb. 1	8 17 21	4	14 , 8	+0 27.37	− 3 18.3	1 2 26.42	+ 8 19 45.8	9.602	0.697	−1.18	−5.5†
4	7 35 41	5	8 , 6	−0 23.14	+ 5 27.2	0 58 18.58	+ 8 12 19.1	9.569	0.689	−1.24	−5.9*
4	7 35 41	6	8 , 6	−0 25.75	− 6 0.4	0 58 18.74	+ 8 12 17.4	9.569	0.689	−1.24	−5.8*
10	6 27 56	7	8 , 6	+1 3.16	− 3 20.8	0 51 2.03	+ 8 1 35.8	9.512	0.680	−1.33	−6.4*
19	6 37 29	8	12 , 8	−0 15.97	+ 5 21.1	0 41 56.30	+ 7 54 11.4	9.591	0.697	−1.43	−7.2*
Apr. 21	16 3 48	9	10 , 8	−0 2.54	+ 3 16.5	23 50 57.84	+ 7 46 28.9	9.662*n*	0.735	−1.12	−8.8*
24	16 22 10	9	10 , 8	−0 41.88	+ 5 43.1	23 50 18.56	+ 7 48 55.8	9.656*n*	0.725	−1.06	−8.5*
30	16 26 17	10	10 , 6	+0 2.21	+16 2.8	23 53 8.39	+ 8 10 36.1	9.644*n*	0.715	−0.93	−7.8*
May 4	15 47 28	11	12 , 8	−0 23.51	+ 0 8.2	0 0 1.95	+ 8 46 47.7	9.658*n*	0.723	−0.88	−7.3†
5	15 47 59	12	8 , 8	−1 48.59	− 6 7.0	0 2 47.06	+ 9 0 26.2	9.658*n*	0.722	−0.89	−7.3*
26	8 4 16	13	11 , 6	+0 4.53	− 2 12.9	9 7 16.37	+ 6 16 26.1	9.533	0.698	−0.14	−0.3*
27	8 0 59	15	6 , 6	+0 13.00	+ 2 12.9	9 19 55.74	+ 5 11 18.7	9.511	0.704	−0.08	−0.2*
June 6	9 9 58	16	8 , 6	−0 52.26	+ 7 16.1	10 14 10.19	+ 0 21 45.8	9.590	0.740	+0.10	−2.3*
7	9 24 59	17	14	−0 4.41	. . . .	10 16 41.65	. . . .	9.602	. . .	+0.11	. . †
7	9 19 50	17	5	. . . .	− 5 50.7	. . . .	+ 0 8 4.3	. . . .	0.741	. . .	−2.4†
8	9 5 47	18	9 , 8	+0 30.40	−10 11.5	10 18 56.55	− 0 4 15.9	9.589	0.743	+0.11	−2.4†
11	8 30 56	19	10 , 6	−0 5.75	+ 1 47.7	10 24 15.24	− 0 36 4.9	9.550	0.745	+0.11	−3.8*

* = J. G. Porter. † = Everett I. Yowell.

Mean Places of Comparison-Stars for 1910.0.

*	α	δ	Authority		*	α	δ	Authority	
	h m s	° ′ ″				h m s	° ′ ″		
1	2 10 20.29	+11 21 49.9	Comp. with 2		11	0 0 26.34	+8 46 46.8	Bonn Kü, 10663	
2	2 10 6.04	+11 18 46.4	Leipzig I, A.G.	660	12	0 4 36.54	+9 6 40.5	Leipzig II, A.G. 16	
3	1 49 12.32	+10 10 50.2	" II. "	722	13	9 7 11.98	+6 18 38.7	B.D. +6°2119 Cp. with	
4	1 2 0.23	+ 8 23 9.6	" " "	401	14	9 8 50.80	+6 19 25.8	Leipzig II, A.G.	5008
5	0 58 42.96	+ 8 6 57.8	" " "	378	15	9 19 42.82	+5 9 6.0	" " "	5103
6	0 58 45.73	+ 8 18 23.6	" " "	379	16	10 15 2.35	+0 14 32.0	Nicolajew, A.G.	3035
7	0 50 0.20	+ 8 5 3.0	" " "	308	17	10 16 45.95	+0 13 57.4	" "	3040
8	0 42 13.70	+ 7 48 57.5	" " "	257	18	10 18 26.04	+0 5 58.0	" "	3046
9	23 51 1.50	+ 7 43 21.2	" " "	11818	19	10 21 50.88	−0 37 48.8	" "	3068
10	23 53 7.11	+ 7 51 41.1	" " "	11830					

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OBSERVATIONS AND ELEMENTS OF THE SATELLITE OF *NEPTUNE*,

MADE WITH THE 26-INCH EQUATORIAL OF THE NAVAL OBSERVATORY,

By ASAPH HALL.

[Communicated by Commodore T. E. De Witt Veeder, U. S. N. Superintendent.]

The observations of *Neptune's* satellite given below were made at the oppositions of 1908-09, and 1909-10. The times, as given, are those of the position-angles, to which the distances have been reduced. Also, they are Paris mean times, and have been corrected for aberration. A complete observation consisted usually of eight settings in position-angle, and eight in distance, four distances on each side of coincidence. The observations were arranged so that the mean of the times of the position-angles agreed very nearly with the mean of the times of the distances.

The value of a micrometer-revolution has been taken as $R = 9''.9328 - 0''.000055\ (T - 28^\circ F)$, the value found by Professor See in 1900-01 from observations of arcs in the *Pleiades* and *Perseus*. The value of a revolution found by me is about the same, though with a somewhat different temperature coefficient. However, for short distances it makes no difference which of the two is used. For a description of the instrument reference may be made to Volume VI, Second Series, of the Publications of the Naval Observatory which is in press, and contains the equatorial observations made from 1903 to 1907, inclusive. The micrometer, Clark II, was somewhat improved in the summer of 1909. See the report of the Superintendent for the fiscal year ending June 30, 1910.

Comparison is made between the observations and the data of the *Connaissance des Temps*, and corrections are found to those data. For the formulae of comparison and the equations of condition see, for example, the *Monthly Notices* of the Royal Astronomical Society, Vol. LXV, p. 570, the paper of Messrs. Dyson and Edney.

dp and *ds* are taken in the sense computed minus observed. They are direct comparisons of the reduced observations with the *Conn. des Temps*. The residuals are obtained by substituting in the weighted observation-equations. The eccentricity is taken = 0.

These computations have been made by Messrs. Frederickson, Eppes, and Burton, assistants in the observatory — Mr. Eppes having made the larger part of them.

Date	Paris M.T.	Obs. *p*	*dp*	*s* sin *dp*	Wt.	*v*	Obs. *s*	*ds*	Wt.	*v*
1908	h m s	°	°	″		″	″	″		″
Dec. 2	14 28 23	257.059	+2.099	+0.562	1	+0.190	15.97	−0.62	1	−0.144
7	14 17 18	295.279	+1.263	+0.356	0.5	−0.033	16.00	+0.14	0.5	+0.318
13	12 51 45	292.274	+1.468	+0.420	1	+0.008	16.55	−0.18	1	+0.145
26	13 0 55	234.203	+0.247	+0.056	1	−0.259	13.44	−0.45	1	−0.016
31	14 49 13	272.425	+2.665	+0.780	1	+0.360	17.00	−0.23	1	+0.246
1909 Jan. 1	14 41 48	218.276	+1.864	+0.389	1	+0.086	11.95	+0.02	1	−0.187
17	11 50 54	307.028	+0.577	+0.151	1	−0.206	15.98	−1.02	1	−0.758
18	9 53 50	267.769	+0.269	+0.077	1	−0.326	17.02	−0.62	1	−0.130
20	15 13 10	116.337	+1.535	+0.427	1	−0.001	16.30	−0.35	1	−0.204
Feb. 10	10 26 19	285.994	+1.713	+0.495	0.5	+0.052	......	.....		....
11	12 30 18	234.580	+2.405	+0.558	1	+0.087	12.99	+0.31	1	+0.438
13	14 43 9	96.165	+1.745	+0.510	1	+0.421	17.41	−0.65	1	−0.359
17	11 38 38	229.225	+1.933	+0.430	1	+0.125	12.89	−0.13	1	0.109
17	14 9 4	222.808	+0.735	+0.156	1	−0.140	11.98	+0.21	1	+0.083
20	12 33 9	44.735	−0.793	−0.169	1	−0.234	12.77	−0.56	1	+0.023
25	12 10 42	90.824	+1.271	+0.366	1	+0.037	17.42	−0.90	1	−0.594
26	12 11 48	35.398	+0.004	+0.001	1	−0.050	12.12	−0.45	1	+0.183

Date	Paris M.T.	Obs. p	dp	$s \sin dp$	Wt.	v	Obs. s	ds	Wt.	v
1909	h m s	°	°	″		″	″	″		″
Mar. 5	11 38 47	307.013	+1.690	+0.427	0.5	+0.059	. . . . . .	. . . .	. . . . .	. . . .
11	10 59 28	301.975	+1.797	+0.469	0.5	+0.073	14.67	+0.28	1	+0.516
15	9 24 58	79.756	+1.324	+0.361	1	+0.108	15.39	+0.22	1	+0.552
17	9 9 58	299.582	+1.878	+0.496	1	+0.121	15.56	−0.42	1	−0.185
20	9 0 8	117.551	+1.319	+0.354	1	−0.063	15.17	+0.20	1	+0.339
21	11 9 36	70.356	+1.284	+0.327	1	+0.079	14.89	−0.28	1	+0.096
21	12 30 21	67.475	+1.217	+0.304	1	+0.132	15.09	−0.79	1	+0.395
22	9 18 7	1.977	+0.145	+0.028	1	−0.059	11.66	−0.74	1	−0.105
23	10 51 0	291.214	+1.436	+0.398	1	−0.005	16.21	−0.32	1	−0.053
26	8 45 7	113.649	+0.129	+0.036	1	−0.375	15.52	+0.25	1	+0.450
Dec. 9	13 49 40	130.774	+1.467	+0.379	1	+0.540	14.57	+0.25	1	+0.169
10	12 21 22	92.422	−0.568	−0.162	0.5	−0.186	. . .	. . . . . .	. . .	. . . .
16	13 2 27	87.772	−2.682	−0.737	1	−0.866	15.47	+0.29	1	+0.313
17	13 43 12	12.589	+0.393	+0.076	0.8	−0.122	11.51	−0.43	1	−0.359
1910 Jan. 7	14 1 30	156.388	−0.912	−0.200	0.5	+0.041	. . .	. . . .	. . . .	. . . . .
8	10 40 15	111.944	−1.795	−0.524	1	−0.518	16.39	+0.35	1	+0.285
8	12 23 39	107.706	−0.488	−0.144	1	−0.162	16.25	+0.59	1	+0.536
10	11 35 9	336.625	+1.863	+0.401	1	+0.139	12.17	+0.15	1	+0.245
10	14 21 58	328.067	+2.082	+0.471	1	+0.193	13.28	−0.30	1	−0.197
19	13 50 26	139.257	+0.577	+0.140	1	+0.346	13.65	+0.28	1	+0.217
29	9 46 37	272.481	+1.415	+0.410	1	+0.055	16.91	−0.31	1	−0.118
29	10 49 6	271.324	+0.755	+0.217	1	−0.131	16.98	−0.49	1	−0.289
29	12 42 25	266.578	+2.133	+0.604	1	+0.268	16.70	−0.46	1	−0.247
Feb. 1	13 11 56	83.307	+1.743	+0.484	1	+0.355	15.84	+0.08	1	+0.093
1	14 57 51	79.810	+1.848	+0.503	0.5	+0.257	16.16	−0.57	0.5	−0.388
7	10 32 48	84.139	+0.292	+0.081	1	−0.050	15.65	+0.20	1	+0.215
7	12 48 30	79.130	+0.902	+0.243	1	+0.100	16.08	−0.66	1	−0.634
10	13 3 34	254.995	+1.477	+0.387	1	+0.120	14.96	+0.08	1	+0.344
13	11 23 4	77.049	−0.178	−0.047	0.5	−0.439	15.36	−0.29	0.5	−0.184
18	12 4 16	112.909	+0.188	+0.054	1	+0.087	16.15	+0.21	1	+0.130
22	12 41 2	243.090	+0.632	+0.151	1	−0.013	13.64	+0.02	1	+0.325
25	10 27 14	65.024	+0.567	+0.137	0.5	−0.025	13.99	−0.15	0.5	−0.075
25	13 19 47	57.273	+0.877	+0.201	1	+0.018	13.47	−0.36	1	−0.317
Mar. 3	11 33 19	52.158	+2.705	+0.604	0.5	+0.298	. . . . .	. . . .	. . . . .	. . . . . .
4	11 7 34	331.444	+0.863	−0.189	1	−0.085	12.53	−0.02	1	+0.077
8	10 19 57	100.569	+0.245	+0.071	1	+0.011	16.47	+0.13	1	+0.090
8	11 4 40	99.417	+0.140	+0.041	0.5	−0.014	. . . . .	. . . .	. . . . .	. . . . .
14	9 56 47	98.163	−1.722	−0.495	0.5	−0.404	16.41	+0.06	1	+0.034
15	10 14 16	39.773	+0.872	+0.178	1	−0.016	11.96	−0.23	1	−0.182
17	11 18 43	271.867	−0.342	−0.097	0.5	−0.309	. . . . .	. . . . .	. . . .	. . . . .
26	9 28 33	85.688	+1.183	+0.326	1	+0.206	16.07	−0.27	1	−0.265
Apr. 2	10 10 55	7.083	+0.968	+0.183	1	−0.036	11.04	−0.21	1	−0.146
8	9 31 46	356.946	+2.290	+0.436	1	+0.206	11.14	−0.22	1	−0.149
9	9 19 48	295.248	+0.627	+0.172	1	−0.178	15.72	0.00	0.8	+0.113
9	10 1 7	. . . .	. . . .	. . . .			15.86	−0.11	0.7	−0.008
13	9 37 47	67.141	+1.263	+0.304	1	+0.133	13.87	−0.07	1	−0.032
14	9 45 32	343.801	+3.797	+0.748	0.5	+0.356	11.40	−0.11	0.5	−0.022

NORMAL EQUATIONS.
1908–09.

	$\sin du$	$\sin dN$	$\sin dI$	$2e \sin Q$	$2e \cos Q$	$\frac{da}{a}$	n
$\sin du$	+1589.10	−245.18	+380.18	+442.07	+240.13	−287.47	−87.563
$\sin dN$		1131.12	−118.33	+170.55	−57.89	+466.66	−30.591
$\sin dI$			+1458.76	+220.63	+33.91	−1294.27	+11.982
$2e \sin Q$				+2412.34	510.25	−94.04	−15.859
$2e \cos Q$					+3494.68	+129.29	−5.842
$\frac{da}{a}$						+5272.89	−104.909

$[nn] = 9.543$

1909–10.

	sin du	sin dN	sin dI	$2e$ sin Q	$2e$ cos Q	$\frac{da}{a}$	n
sin du	+5658.22	− 162.14	+ 205.95	−1394.07	+1781.88	− 366.99	− 57.082
sin dN		+1478.21	− 251.06	− 287.89	− 890.42	+ 772.84	− 13.821
sin dI			+1790.30	+ 440.70	− 30.45	−1525.48	+ 12.307
$2e$ sin Q				+2998.20	− 722.85	− 131.77	− 3.091
$2e$ cos Q					+4274.77	− 986.55	− 52.676
$\frac{da}{a}$						+6357.29	− 24.721

$[nn] = 6.561$

RESULTS 1908–09.

$$\sin du = +0.02135 \pm 0.00331 \qquad du = +1^\circ\!.223 \pm 0^\circ\!.190$$
$$\sin dN = +0.02340 \pm 0.00669 \qquad dN = +1^\circ\!.341 \pm 0^\circ\!.383$$
$$\sin dI = +0.00700 \pm 0.00657 \qquad dI = +0^\circ\!.401 \pm 0^\circ\!.376$$
$$2e \sin Q = +0.00005 \pm 0.00462 \qquad Q = 179^\circ\!.51$$
$$2e \cos Q = -0.00541 \pm 0.00379 \qquad e = 0.00271$$
$$\frac{da}{a} = +0.02115 \pm 0.00347 \qquad da = +0''\!.344 \pm 0''\!.056$$

	Sum of Squares of Resid.	Sum of Weights	p.e. one Obs. Wt. Unity
sdp	0.938	25.0	$\pm 0''\!.143$
ds	3.868	24.5	± 0.304
$[vv]$	4.806	49.5	± 0.218

RESULTS 1909–10.

$$\sin du = +0.00910 \pm 0.00283 \qquad du = +0^\circ\!.521 \pm 0^\circ\!.162$$
$$\sin dN = +0.01914 \pm 0.00546 \qquad dN = +1^\circ\!.097 \pm 0^\circ\!.313$$
$$\sin dI = -0.00483 \pm 0.00514 \qquad dI = -0^\circ\!.277 \pm 0^\circ\!.294$$
$$2e \sin Q = +0.01165 \pm 0.00382 \qquad Q = 37^\circ\!.34$$
$$2e \cos Q = +0.01527 \pm 0.00338 \qquad e = 0.00960$$
$$\frac{da}{a} = +0.00354 \pm 0.00274 \qquad da = +0''\!.058 \pm 0''\!.045$$

	Sum of Squares of Resid.	Sum of Weights	p.e. one Obs. Wt. Unity
sdp	2.692	30.8	$\pm 0''\!.202$
ds	2.093	29.5	± 0.191
$[vv]$	4.785	60.3	± 0.187

Applying, then, the corrections as found to the elements of the *Conn. des Temps* the following new elements are obtained, corresponding to the epochs as given. They refer to the equinox of date, and the times are corrected for aberration:

1909 Feb. 12, 2^h Paris M.T.	1910 Feb. 13, 12^h Paris M.T.
$u = 260^\circ\!.077$	$u = 25^\circ\!.137$
$N = 189.317$	$N = 189.222$
$I = 116.597$	$I = 115.751$
$a = 16''\!.61$	$a = 16''\!.33$
$Q = 179^\circ\!.51$	$Q = 37^\circ\!.34$
$e = 0.00271$	$e = 0.00960$

Evidently there is a large personal equation in the distance pointings. At the second opposition a good deal more attention was given to the distances than at the first. With the box-screw the bright wires were shifted back and forth a number of times, so as to judge whether the setting could be improved.

As will be seen from the Equatorial Volume, referred to above, the long wires of the micrometer are illuminated by two lamps on a collar having a slight rotary motion. The lamps are placed at an angle of about 45° to the tube of the telescope and are 180° apart. The position-angles are measured with the middle long wire, which is illuminated, I think, symmetrically, although there is a spot of light on each side of the field, due to the inclination of the lights to the axis of the telescope. The illumination of the short wires is not quite symmetrical. It comes from a lamp at the end of the micrometer box, the light being reflected back from a mirror on the opposite side.

After the observations of *Neptune's* satellite made at a few more oppositions shall have been reduced, new values of the motions of N and I ought to be obtained, as well as a new value for the time of rotation of the pole of the satellite's orbit.

OBSERVATIONS OF COMETS,

MADE WITH THE 26-INCH AND THE 12-INCH EQUATORIALS AT THE U.S. NAVAL OBSRVATORY.

[Communicated by Commodore T. E. De Witt Veeder, U. S. N., Superintendent.]

1910 Wash. M.T.	*	Comp.	Δα	Δδ	App. α	App. δ	log pΔ		Red. to App. Pl.	
					Halley's Comet.					
h m s			m s	′ ″	h m s	° ′ ″			s	″
Apr. 22 16 11 53	1	18 , 6	−0 22.17	+3 39.0	23 50 38.24	+ 7 46 51.2	9.662*n*	0.729	−1.11	− 8.7‡
26 16 20 43	2	9 , 3	+0 8.57	−0 6.7	23 50 31.45	+ 7 53 3.9	9.654*n*	0.720	−1.03	− 8.4‡
28 16 20 23	2	30 , 6	+1 1.30	+6 45.9	23 51 24.24	+ 7 59 56.7	9.652*n*	0.718	−0.97	− 8.2‡
May 4 15 59 21	3	20 , 5	−0 25.45	−0 0.6	0 0 0.24	+ 8 46 38.5	9.655*n*	0.717	−0.88	− 7.4‡
6 16 13 43	4	20 , 4	+4 34.74	+3 50.5	0 6 4.91	+ 9 16 34.7	9.648*n*	0.709	−0.85	− 7.3*
12 15 58 47	5	30 , 6	+0 45.92	+4 7.2	0 47 36.91	+12 21 45.3	9.666*n*	0.713	−0.90	− 5.8*
15 16 19 42	6	5 , 1	+9 20.35	−9 41.7	1 44 8.38	+15 47 12.3	9.676*n*	0.718	−1.03	− 4.4*
29 8 43 55	7	30 , 6	+0 52.50	−1 52.3	9 35 51.43	+ 3 34 16.3	9.567	0.719	−0.01	− 0.9*
30 8 32 55	8	30 , 6	−1 2.11	+3 45.4	9 46 31.98	+ 2 56 8.5	9.540	0.721	+0.05	1.3*
June 3 9 40 58	9	25 , 5	+2 2.39	−9 52.5	10 4 58.19	+ 1 11 34.9	9.620	0.735	+0.06	− 1.8*
7 8 46 52	10	25 , 5	+1 32.43	−5 52.5	10 16 34.87	+ 0 8 37.4	9.563	0.739	+0.10	− 2.3*
					Comet 1910 *b* (Metcalf).					
Aug. 23 8 29 11	11	25 , 5	−1 9.89	+0 2.8	15 47 36.45	+16 12 41.0	9.502	0.586	+1.12	+ 2.9‡
30 8 1 2	12	24 , 5	−0 51.98	−9 43.6	15 39 31.43	+16 37 56.9	9.518	0.585	+0.97	+ 3.1‡
Sept. 26 8 3 29	13	25 , 5	−0 28.75	+1 36.7	15 26 13.99	+17 46 27.3	9.665	0.669	+0.49	+ 1.3†
28 6 59 22	14	25 , 5	−0 42.84	−3 29.8	15 26 1.81	+17 51 45.8	9.620	0.622	+0.47	+ 1.0‡
					Comet 1910 *e* (*Cerulli*)					
Nov. 11 8 47 5	15	30 , 6	−1 44.28	+6 45.7	3 38 26.95	+ 8 9 16.7	9.564*n*	0.686	+3.17	+16.8‡
20 7 22 41	16	25 , 5	+2 33.78	−3 22.7	3 37 31.22	+ 6 7 16.9	9.618*n*	0.712	+3.26	+16.5‡
30 8 20 47	17	30 , 8	+0 5.66	+3 22.0	3 36 42.34	+ 4 24 14.4	9.469*n*	0.706	+3.31	+15.6‡
Dec. 8 10 53 53	18	25 , 5	+2 14.25	+2 32.8	3 37 5.46	+ 3 32 47.6	8.696	0.705	+3.36	+15.1‡

Observers * = A. Hall, ‡ = J. B. Eppes, † = H.E. Burton.

The observations of Halley's comet on April 28, that of 1910 *b* on August 23, and the four of 1910 *e* were made with the 12-inch equatorial.

The observation of comet 1910 *b* on August 23 is poor.

NOTES AND ESTIMATED DIMENSIONS ON HALLEY'S COMET.

April 22. Jets are being thrown out at position angle 153° and the envelope is not symmetrical about head.

May 4. Diameter of head 13″, position angle of jets 109°; position angle of tail 260°; distance from centre of head to extremity of jets (toward Sun and in the direction of the axis of the tail) 24″; length of tail 11°; estimated magnitude of nucleus $2^{M}.5$ of whole comet $1^{M}.0$.

May 6. Haze, length of tail 14°.

May 12. Tail appears to have opened out further and not to go back as straight as it previously did; length 28°. Haze and cloud.

May 15. Length of tail 80° against dark sky before rising of comet

May 16 Length of tail 60° before rising.

May 18. Tail seen from 1:40 until 3:30 A.M., when it faded out in dawn; length 115°. Evidently earth had not yet gone through principal part of tail.

May 27. Length of tail 45°.

June 7. Plainly visible to naked eye; tail about 3° long, as seen from inside of dome.

Mean Places of Comparison-Stars for the beginning of the Year.

*	α	δ	Authority		*	α	δ	Authority	
	h m s	° ′ ″				h m s	° ′ ″		
1	23 51 1.52	+ 7 43 20.9	A.G. Leipzig II	11818	10	10 15 2.34	+ 0 14 32.2	A.G. Nicolajew	3035
2	23 50 23.91	+ 7 53 19.0	" " "	11813	11	15 48 45.22	+16 12 35.3	A.G. Berlin A	5675
3	0 0 26.57	+ 8 46 46.5	" " "	11870	12	15 40 22.44	+16 47 37.4	" " "	5632
4	0 1 31.02	+ 9 12 51.5	" " "	11874	13	15 26 42.25	+17 44 19.3	" " "	5564
5	0 16 51.89	+12 17 13.9	A.G. Leipzig I	231	14	15 26 44.18	+17 55 11.6	" " "	5565
6	1 31 49.06	+15 56 58.4	A.G. Berlin A	473	15	3 10 8.06	+ 8 2 14.2	A.G. Leipzig II	1377
7	9 31 58.91	+ 3 36 9.5	A.G. Albany	3837	16	3 34 51.18	+ 6 10 23.1	" " "	1345
8	9 47 34.04	+ 2 52 21.1	" "	3893	17	3 36 33.37	+ 4 20 36.8	A.G. Albany	1077
9	10 2 55.74	+ 1 21 29.2	" "	3961	18	3 34 17.85	+ 3 29 59.7	" "	1062

SUNSPOT OBSERVATIONS,

MADE AT BERWYN, PENN., WITH A 4½-INCH REFRACTOR,

By A. W. QUIMBY.

1910	Time	New	Total		Fac.	Def.
		Grs.	Grs.	Spots	Grs.	
July 1	6	1	1	2	1	fair
2	8	–	1	4	1	"
3	6	–	1	4	–	"
4	6	2	3	16	1	"
5	6	–	2	4	1	poor
6	6	–	2	6	2	fair
7	6	–	1	4	2	"
8	6	1	2	8	2	"
9	6	–	2	4	1	"
10	6	–	1	2	–	poor
11	6	–	2	4	1	fair
12	6	1	1	1	1	"
13	6	–	1	1	1	"
14	6	–	1	2	1	"
15	6	–	1	2	1	"
16	6	–	1	2	–	"
17	6	–	1	2	–	"
18	6	–	1	2	–	"
19	6	–	–	–	1	"
20	6	–	–	–	1	"
21	6	–	–	–	–	"
22	6	–	–	–	1	"
23	6	–	–	–	2	"
24	6	–	–	–	1	"
25	6	–	–	–	1	"
26	6	–	–	–	–	"
27	6	2	2	3	1	"
28	6	–	2	4	2	"
29	6	–	1	3	3	"
30	6	–	2	5	1	"
31	6	–	1	1	–	"
Aug. 1	6	–	2	3	–	"
2	6	–	1	11	–	good
3	6	–	1	9	–	fair
4	4	1	2	5	2	"
5	6	–	2	3	1	"
6	6	–	2	6	1	"
7	6	–	1	5	1	"
8	6	1	2	8	1	"
9	6	–	2	7	2	"
10	4	–	2	8	1	"
11	9	–	1	7	–	"
12	6	–	1	5	–	"
13	6	–	1	3	1	"
14	6	–	1	1	1	"
15	8	–	1	1	1	poor
16	10	1	1	3	–	"
17	8	–	1	5	–	fair
18	8	–	1	3	–	poor
*19	4	–	–	–	–	fair
*20	6	–	–	–	–	"
*21	6	–	–	–	–	"
*22	6	–	–	–	–	"
*23	6	–	–	–	–	"
*24	7	–	–	–	–	"
*25	2	–	–	–	–	"
*26	7	–	–	–	–	poor
*27	4	–	–	–	–	fair
*28	6	–	–	–	–	"
Aug. *29	4	–	–	–	–	fair
30	6	–	–	–	–	"
31	6	1	1	1	1	"
Sept. 2	4	–	1	1	–	"
3	1	–	1	1	–	poor
4	6	1	2	5	–	fair
5	1	–	2	10	1	"
6	6	–	2	5	2	"
7	6	1	2	3	1	"
8	6	–	2	2	–	poor
9	6	–	2	3	–	fair
10	6	–	2	2	1	"
11	6	–	2	2	1	"
12	6	–	–	–	–	"
13	6	–	–	–	–	"
14	6	–	–	–	1	"
15	6	–	–	–	–	"
16	6	–	–	–	1	"
17	6	–	–	–	2	"
18	6	–	–	–	1	"
19	9	–	–	–	–	poor
20	9	2	2	6	1	fair
21	6	–	2	6	1	"
22	6	–	2	2	1	"
23	6	–	2	5	1	"
24	1	–	2	6	–	"
25	6	–	2	5	2	"
26	8	1	3	10	1	"
27	6	1	4	10	2	"
28	6	1	4	45	3	good
29	6	–	3	36	2	fair
30	6	–	3	50	2	"
Oct. 1	8	–	3	50	1	"
2	7	–	2	48	1	"
3	7	–	1	32	1	poor
4	7	–	1	20	1	"
5	10	–	1	16	–	fair
6	8	–	1	12	1	"
9	8	1	1	4	–	poor
10	7	1	2	4	–	fair
11	7	–	1	4	–	"
12	7	–	1	9	–	"
13	7	–	1	4	1	"
14	7	–	1	2	2	"
15	7	–	–	–	1	"
16	7	1	1	1	2	"
17	7	–	1	2	3	"
18	7	1	2	8	1	"
19	7	–	2	18	1	"
20	7	–	1	5	–	poor
21	9	2	3	24	1	fair
22	4	1	4	26	1	poor
23	7	–	4	27	1	fair
24	8	–	3	20	1	"
25	10	–	3	26	2	"
26	8	1	4	28	1	"
27	8	–	2	9	1	poor
28	8	–	1	4	1	"
29	8	–	1	2	1	fair
Oct. 30	8	–	–	–	1	fair
31	8	1	1	3	1	"
Nov. 1	8	–	1	3	–	poor
2	8	–	1	2	2	fair
5	9	–	–	–	–	"
6	8	–	–	–	–	"
7	8	1	1	1	–	"
8	8	–	–	–	1	"
9	8	–	–	–	1	"
10	8	–	–	–	1	"
11	8	–	–	–	2	"
12	8	–	–	–	1	"
13	8	–	–	–	2	"
14	8	–	–	–	1	"
15	8	–	–	–	–	"
16	8	1	1	3	–	"
17	8	–	1	4	–	poor
18	8	1	2	5	1	fair
19	8	–	2	3	1	"
20	8	1	1	1	2	"
21	8	–	1	1	2	"
22	8	–	1	1	2	"
23	8	–	1	2	1	"
24	8	–	–	–	1	"
25	8	–	–	–	–	"
26	8	–	–	–	–	"
27	8	–	–	–	–	"
29	12	–	–	–	–	poor
30	10	–	–	–	–	fair
Dec. 1	8	–	–	–	–	poor
2	8	–	–	–	–	fair
3	9	–	–	–	–	"
4	9	–	–	–	–	"
5	8	–	–	–	–	"
7	8	–	–	–	–	"
8	8	–	–	–	–	"
9	8	1	1	2	1	"
10	8	–	1	2	1	"
11	2	1	2	3	–	"
12	8	–	2	5	–	"
13	8	–	2	5	–	"
14	8	–	2	3	–	poor
15	8	–	1	1	–	"
16	8	–	1	1	–	fair
17	8	–	–	–	–	"
18	8	1	1	2	2	"
19	8	–	1	3	1	"
20	8	–	1	1	1	"
21	8	–	1	1	–	"
22	8	–	–	–	–	"
23	8	–	–	–	–	"
24	8	–	–	–	–	"
25	8	–	–	–	–	"
26	8	–	–	–	–	"
27	8	–	–	–	–	"
28	8	–	–	–	–	"
29	8	–	–	–	–	poor
30	2	–	–	–	–	"
31	8	–	–	–	–	fair

* 2½″ refractor.

OCCULTATIONS OF STARS BY THE MOON,

MADE WITH THE 26-INCH AND THE 12-INCH EQUATORIALS AT THE U.S. NAVAL OBSERVATORY.

[Communicated by Commodore T. E. DE WITT VEEDER, U.S.N. Superintendent.]

Date	Object	Phen.	Wash. Sid. T.	Wash. M.T.	See'g	Instrum't	Pow'r	Obs.	Remarks
1909			h m s	h m s					
Aug. 29	154 B *Capricorni*	D D	23 37 14.2	13 6 2.3	f	12-inch	335	F	
30	69 *Aquarii*	D B	21 42 4.2	11 7 15.2	f	12-inch	115	E	
30	69 *Aquarii*	R B	22 45 47.7	12 10 48.2	f	12-inch	115	E	
30	τ *Aquarii*	D B	23 1 27.3	12 26 25.3	g	12-inch	115	E	
30	τ *Aquarii*	R B	0 15 7.5	13 39 53.4	g	12-inch	115	E	
Sept. 1	*Mars* I	D B	19 24 13.7	8 41 55.5	f	26-inch	175	E	
	II	D B	19 24 45.7	8 42 27.4	.	.....	..	..	
1	*Mars* I	R D	20 21 33.1	9 39 5.5	f	26-inch	175	E	
	" II	R D	20 22 15.1	9 39 47.4	.	. . .	. .	.	
1	*Mars* I	D B	19 24 13.2	8 41 55.0	p	12-inch	235	F	
	" II	D B	19 24 48.7	8 42 30.4	.	. .	.		
1	*Mars* I	R D	20 21 33.8	9 39 6.2	p	12-inch	235	F	Late.
	" II	R D	20 22 15.2	9 39 47.5	.	. .	. . .		
25	33 *Capricorni*	D D	1 9 59.1	12 52 22.4	f	12-inch	115	F	
28	33 *Piscium*	D D	18 39 35.6	6 11 15.2	p	12-inch	115	F	Moon near horizon, limb unsteady.
28	33 *Piscium*	R.B	19 37 51.3	7 9 21.4	p	12-inch	115	F	
28	24 B *Ceti*	D D	21 16 23.2	8 47 37.1	b	12-inch	160	F	Star faint, obs. somewhat indef.
29	26 *Ceti*	R D	21 13 39.3	8 40 57.7	. .	12-inch	115	F	
29	33 *Ceti*	D B	0 7 39.2	11 34 29.1	p	12-inch	335	F	
29	33 *Ceti*	R D	1 20 51.8	12 47 29.7	p	12-inch	335	F	
Nov. 19	37 *Capricorni*	D D	0 29 21.5	8 35 36.5	g	12-inch	115	E	
19	37 *Capricorni*	R B	1 28 2.8	9 34 8.2	p	12-inch	115	E	Haze, probably late 1^s.
26	B.D. + 20 710	D D	6 35 29.0	14 13 12.6	g	26-inch	175	E	
26	B.D. + 20 710	R D	7 23 8.7	15 0 44.5	g	26-inch	175	E	
26	Star *b*	D D	7 0 8.7	14 37 48.3	g	26-inch	175	E	
26	Star *b*	R D	8 10 52.7	15 48 20.7	g	12-inch	115	H	
26	B.D. + 20 713	D D	7 10 54.2	14 48 32.0	g	26-inch	175	E	
26	B.D. + 20 713	R D	8 18 35.8	15 56 2.5	g	26-inch	175	E	
26	B.D. + 20 713	D D	7 10 54.6	14 48 32.4	g	12-inch	115	H	
26	B.D. + 20 713	R D	8 18 38.1	15 56 1.8	g	12-inch	115	H	Probably 2^s late.
26	B.D. + 20 715	D D	7 31 44.8	15 12 18.7	g	26-inch	175	E	
26	B.D. + 20 715	D D	7 34 41.8	15 12 18.7	g	12-inch	115	H	
26	B.D. + 20 715	R D	8 14 13.9	15 51 41.4	g	12-inch	115	H	
26	B.D. + 20 716	D D	7 46 10.8	15 24 12.8	g	26-inch	175	E	
26	B.D. + 20 716	D D	7 46 40.8	15 24 12.8	g	12-inch	115	H	
26	B.D. + 20 716	R D	8 39 4.8	16 16 28.2	g	12-inch	115	H	

Date	Object	Phen.	Wash. Sid. T.	Wash. M.T.	See'g	Instrum't	Pow'r	Obs.	Remarks
1909			h m s	h m s					
Nov. 26	Star *c*	D D	8 0 25.3	15 37 55.0	g	26-inch	175	E	Chronograph record doubtful
26	Star *c*	R D	8 59 34.3	16 36 54.3	g	26-inch	175	E	
26	Star *e*	D D	8 27 21.0	16 4 46.4	g	26-inch	175	E	
26	Star *g*	D D	8 12 29.2	15 49 56.9	g	26-inch	175	E	
26	Star *d*	R D	9 3 52.8	16 41 12.1	g	26.inch	175	E	
26	Star *f*	D D	8 36 15.1	16 13 39.0	g	26-inch	175	E	
26	Star *f*	R D	9 9 21.4	16 46 39.8	g	26-inch	175	E	Possibly late.
26	Star *f*	D D	8 36 12.4	16 13 36.3	g	12-inch	115	H	
26	B.D. + 20 719	D D	8 50 26.4	16 27 47.9	g	26-inch	175	E	
26	B.D. + 20 719	D D	8 50 23.3	16 27 44.8	g	12-inch	115	H	
26	B.D. +20 721	D D	9 2 41.3	16 40 0.8	g	26-inch	175	E	
26	B.D. + 20 721	D D	9 2 43.6	16 40 3.1	g	12-inch	115	H	
26	B.D. + 20 718	R D	9 37 21.3	17 14 35.1	f	26-inch	175	E	Poor observation.
Dec. 22	31 *Arietis*	D D	1 22 10.8	7 18 32.1	f	12-inch	115	E	
	31 *Arictis*	R B	2 8 16.5	8 4 30.2	f	12-inch	115	E	
1910 May 19	46 *Virginis*	D D	14 19 54.3	10 32 13.5	f	26-inch	375	B	Haze and clouds, but steady.
	46 *Virginis*	R B	15 24 28.2	11 36 36.9	p	26-inch	375	B	Clouds, late by perhaps 3^s.
July 24	e *Aquarii*	R D	21 20 35.5	13 12 15.7	.	26-inch	. . .	B	
Aug. 27	99 *Tauri*	D B	1 30 28.9	15 7 47.2	f	26-inch	375	Hl	
27	99 *Tauri*	R D	2 22 15.2	15 59 25.0	f	26-inch	375	Hl	
Oct. 15	336 B *Aquarii*	D D	0 1 57.5	10 26 50.8	g	12-inch	160	B	
24	28 *Cancri*	D B	3 33 39.3	13 22 34.8	f	26-inch	375	Hl	Clouds.
24	28 *Cancri*	R D	4 27 46.2	14 16 32.8	f	26-inch	375	Hl	
24	υ^1 *Cancri*	D B	5 1 16.1	14 49 57.2	f	26-inch	375	Hl	
24	υ^1 *Cancri*	R D	5 58 15.1	15 46 46.9	f	26-inch	375	Hl	
24	υ^1 *Cancri*	D B	5 1 15.7	14 49 56.8	p	12-inch	160	B	Haze, observation poor.
24	υ^1 *Cancri*	R D	5 58 15.5	15 46 47.3	p	12-inch	160	B	Haze, observation poor.
24	υ^2 *Cancri*	D B	6 1 5.6	15 49 36.9	f	26-inch	375	Hl	
24	υ^2 *Cancri*	R D	6 34 17.1	16 22 42.9	f	26-inch	375	Hl	
24	υ^2 *Cancri*	D B	6 1 4.9	15 49 36.2	p	12-inch	160	B	
24	υ^2 *Cancri*	R D	6 34 17.1	16 22 43.0	f	12-inch	160	B	
Nov. 7	248 B *Sagittarii*	D D	22 6 34.9	7 1 21.2	g	12-inch	115	E	
17	284 B *Tauri*	D B	22 34 50.4	6 50 12.9	p	12-inch	115	E	Thin clouds.
17	315 B *Tauri*	D B	7 55 33.4	16 9 24.1	g	12-inch	85	E	
17	315 B *Tauri*	R D	9 1 3.9	17 14 43.8	g	12-inch	85	E	

Date	Object	Phen.	Wash. Sid. T.	Wash. M.T.	See'g	Instrum't	Pow'r	Obs.	Remarks
			h m s	h m s					
1909 Nov. 20	4 *Cancri*	D B	2 4 13.7	10 7 14.2	f	12-inch	115	E	
20	4 *Cancri*	R D	3 3 22.1	11 6 13.0	g	12-inch	115	E	
22	η *Leonis*	D B	8 57 2.7	16 51 3.7	g	12-inch	235	B	
22	η *Leonis*	R D	10 16 39.3	18 10 27.4	g	12-inch	235	B	
22	η *Leonis*	D B	8 56 59.	16 51 0.	g	. . . . .	34	E	Eye and ear, with 4-in.finder.
22	η *Leonis*	R D	10 16 39.	18 10 27.	g	. . .	34	E	Eye and ear, with 4-in. finder.
Dec. 14	192 B *Tauri*	D D	4 23 55.6	10 52 11.4	f	26-inch	375	Hl	
14	192 B *Tauri*	R B	5 36 4.3	12 4 8.2	f	26-inch	375	Hl	
14	υ *Tauri*	D D	10 35 15.8	17 2 30.7	f	12-inch	115	E	
14	72 *Tauri*	D D	10 55 57.1	17 23 8.6	p	12-inch	115	E	

STARS OBSERVED DURING THE LUNAR ECLIPSE OF NOV. 26, 1909.

Star	Mag.	α 1910.0	δ 1910.0	Star	Mag.	α 1910.0	δ 1910.0
		h m s	° ′			h m s	° ′
B.D. +20 710	9.5	4 5 0.7	+20 23.6	*g*	11	4 8 34.8	+20 23.4
b	10	4 6 17.8	+20 19.5	*f*	10	4 8 54.9	+20 38.5
B.D. +20 713	9.5	4 6 45.1	+20 15.5	*e*	10	4 9 17.6	+20 18.8
B.D. +20 715	9.0	4 6 55.9	+20 30.8	B.D. +20 718	9.5	4 9 38.6	+20 25.3
B.D. +20 716	9.0	4 7 31.0	+20 30.3	B.D. +20 719	9.5	4 10 4.2	+20 29.8
c	10	4 8 16.1	+20 21.4	B.D. +20 721	8.1	4 10 24.3	+20 35.7
d	10	4 8 21.2	+20 24.1				

In third column DD signifies star disappeared at dark limb of Moon; DB, disappeared at bright limb; RD, reappeared at dark limb; RB, reappeared at bright limb. All observations recorded on chronograph except as noted under Remarks.

Observers: Hl = A. HALL; H = G. A. HILL; F = MATT FREDERICKSON; E = J. B. EPPES; B = H. E. BURTON.

EPHEMERIS OF MINOR PLANET, LEHIGH (691),

BY JOSEPH B. REYNOLDS.

Gr. Noon	App. α	App. δ	log Δ	Gr. Noon	App. α	App. δ	log Δ
1911	h m s	° ″		1911	h m s	° ″	
Feb. 16	12 23 32	+16 29.4	0.39006	Mar. 24	11 59 28	+20 6.3	0.37700
20	21 43	+16 56.9	0.38556	28	56 22	+20 20.6	0.37960
24	19 36	+17 24.5	0.38172	Apr. 10	53 22	+20 32.0	0.38298
28	17 12	+17 51.8	0.37861	5	50 30	+20 40.4	0.38707
Mar. 4	14 35	+18 18.3	0.37628	9	47 48	+20 45.6	0.39182
8	11 46	+18 43.7	0.37476	13	45 20	+20 47.7	0.39718
12	8 48	+19 7.5	0.37408	17	43 6	+20 46.8	0.40307
16	5 44	+19 29.5	0.37422	21	41 9	+20 43.0	0.40943
20	2 36	+19 49.1	0.37520	25	11 39 28	+20 36.3	0.41620

± $1^m = \mp 6'$. Magn. at opposition = $13^M.4$, March 21.

Lehigh University, South Bethlehem, Penn.

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PRECESSION AND SOLAR MOTION.

Third Paper. Relation of Systematic Motions to Spectral Types.

By LEWIS BOSS.

At the close of my recent discussion upon the elements of solar motion there was exhibited (*A.J.* 614, p. 122) a phenomenon which seems to call for further inquiry. As the most natural arrangement I had been considering the motions with relation to Galactic latitude, and I found that not only does the mean proper-motion of stars in classes diminish with proximity to the Milky Way (a fact that was known before) but the ratio of the mean proper-motion, μ_0'', to the parallactic motion, M, also diminishes with Galactic latitude. The significance of this lay in the probability, that the mean proper-motion, μ_0'', is small at low Galactic latitude, not only because of the effect of greater mean distance of those stars, but additionally because the component of linear motion projected on the sky, or the linear motions themselves, must be, in the mean, actually smaller relative to those in higher latitudes.

It has been conjectured from the first that there might be a tendency of the large motions, at least, to have, in the mean, a rather low inclination to the Galactic plane; and if, as SCHWARZSCHILD has suggested, there exists a tendency of the peculiar motions to have a preference for a given direction in that plane, the projections of the motions on the sky would be seriously modified in different regions of sky. For the entire sphere the ratio, $\mu_0'' : M$, would be modified, though probably not to a sufficient degree to account for the observed amount.

Thus we seemed to be thrown back upon the hypothesis already suggested, that the mean of the actual linear motions of the stars themselves must be smaller at low Galactic latitudes. It seemed preferable to examine this question before proceeding to investigate the evidence for tendency toward larger proper-motions in certain directions. This resolved itself into an investigation of the peculiar motions of stars arranged in accordance with stellar types.

The possibility that stars of various types have different velocities was brought definitely to my attention in 1903 by the publication of *Radial Velocities of Twenty Stars Having Spectra of the Orion Type*, by EDWIN B. FROST and WALTER S. ADAMS, Vol. VIII of the *Decennial Publications of the University of Chicago*. Upon request I had furnished the proper-motions for those stars in advance from my computations then in progress. Even this small number of stars not only indicated that the proper-motions of the Helium stars were very small in the mean, but also that this motion was in great part parallactic. Consequently it was then evident to me that the peculiar motions of those 20 stars of Type B were in general very small relative to the proper-motion. Furthermore, after allowing for the effect of solar motion Professor FROST estimated that the mean radial motion, ρ, of the 20 stars under consideration is only 7 kilometers per second, leading to about 14 km. for the mean linear motion of those stars. From 280 stars of various types CAMPBELL had already found the mean radial velocity to be 17 km. per second, from which one might infer that the mean peculiar motion of a star is over 30 km. (*Ap. J.*, Vol. XIII, No. 1 January, 1901). The impression made by such data is modified by its various uncertainties arising from the small number of objects, from the difficulty in accurate measurement of spectra in the B-type, and from the obstacle interposed by the binary character of so large a proportion of stars of the first type. It did not seem to me at the time very conclusive though it was quite sufficient to excite a lively desire for further evidence of observation. The investigation by KAPTEYN contained in Vol. XXXI, April, 1910, of the *Astrophysical Journal*, and by KAPTEYN and FROST in the same Journal, Vol. XXXII, July number, 1910, produced such evidence. It appeared to warrant the labor of thoroughly treating the proper-motions of my *Preliminary General Catalogue*, arranged in stellar types. Thus I decided to reverse the intended order of treatment between this section of my work and that which relates to any possible systematic tendency of the peculiar motions of the stars to be larger in any given direction.

The long-continued observations made at the Harvard Observatory and in its Southern branch at Arequipa have provided a reliable basis of classification of stars brighter than $6^{M}.5$ (Harvard scale) into their spectral types much superior to anything that was available previous to the publication of the *Harvard Revised Photometry* (Vol. L) in 1908. In the practical use of this material some uncertainity must arise in fixing the most advantageous limits at which the division into classes should be made. A preliminary trial having shown that mean proper-motion varies very distinctly between successive subdivisions of the Harvard classification in the earlier types it seemed best to make use of the proper-motions themselves for assistance in deciding upon a grouping for the general types *B*, *A*, and *F*. This process revealed some interesting features and, at the same time, bore very strong testimony to the faithfulness with which the Harvard observers had adhered to the type-standards in making the subdivisions. In preparing for this discussion the proper-motions of the *P. G. C.* that are of stars fainter than $6^{M}.5$, *H. R. P.*, were necessarily excluded from the list as previously adopted in the discussions of the first and second papers in this series described in *A.J.*, Nos. 612 and 614 respectively. All proper-motions having a probable error greater than about ±1″.2 were rejected as not sufficiently precise for the purpose here required. In the case of double stars the faint companions were excluded, except in the case of binaries for which the proper-motion of the mean, or the center of gravity, could be adopted. Of the stars of the type *O*, *Oe* 5 was included in type-*B*, and the few other stars of type *O*, as well as the few of type *N*, were excluded altogether. Thus there remained 4,686 stars available for this discussion. These include no stars having apparent proper-motion greater than 20″. The limits actually adopted are described in *A.J.*, No. 612, pp. 88, 89.

The adopted classification, as actually used in this paper, is exhibited in Table I.

In arriving at the classification in Table I, subdivisions of the first three types had been made as shown in the section "Subdivisions" at the end of Table I. Further subdivisions confirmed the reliability of those shown in the table. They show a progressive increase of μ_0'' (group-means of proper-motions) from *B* to *F*. Among the most striking features of these tables are:

1. The smallness of the mean μ_0'' (2″.40) for type-*B*.
2. The isolated large value of μ_0'' (7″.71) for type-*F*.
3. The suddenness with which mean μ''_0 increases from pure *A* to pure *F*; and with which it diminishes from *F* to *G*, a diminution which appears to be almost wholly due to the distribution of *F*-stars in a volume of space comparatively near the Sun, as will appear.

TABLE I. MEAN PROPER-MOTIONS ARRANGED ACCORDING TO STELLAR TYPES.

Type-Name	Limits	No. Stars	Mean P.M.
			″
B	Oe5 to B5	490	2.40
A	*B8* to *A4*	1647	4.56
F	*A5* to *F8*	656	7.71
G	*G* entire	444	5.24
K	*K* entire	1227	5.74
M	*M* entire	222	4.99

Subdivisions.

		″
B8 and *B9*	217	3.82
A	1157	4.62
A2 to *A4*	273	5.53
A5 to *A8*	164	7.07
F	287	7.91
F2 to *F8*	205	7.93

In order to give a more complete idea of the distribution in space of the bright stars of various types, limited as already described, but amplified to include also stars brighter than $6^{M}.5$, *H. R. P.*, that have motions greater than those employed in the present paper, the motions are classified in Table II. The *P. G. C.* is complete only for stars down to the sixth magnitude of its own scale (*H. R. P.* $5^{M}.7$), so that this tabulation has no great value for purposes of general investigation. But it ought to give a fairly good idea of the comparative spatial relations of the types of stars with which we are dealing.

TABLE II. DISTRIBUTION OF PROPER-MOTIONS BY TYPES.

P.M. Limits	*B*	*A*	*F*	*G*	*K*	*M*
″ ″						
0 to 1.9	238	392	97	107	218	48
2.0 to 3.9	164	533	115	111	327	54
4.0 to 5.9	76	294	81	86	231	51
6.0 to 7.9	8	179	74	48	167	33
8.0 to 9.9	4	103	76	34	95	15
10.0 to 11.9	..	56	66	22	78	10
12.0 to 13.9		45	56	18	73	11
14.0 to 15.9		31	47	14	40	2
16.0 to 19.9		28	76	16	51	1
20.0 to 24.9	1	16	57	18	16	5
25.0 to 34.9		13	77	21	34	2
35.0 to 44.9		2	34	16	8	1
45.0 to 54.9		1	25	8	11	1
55.0 to 64.9			12	7	4	
65.0 to 80.0			9	5	8	
80.1 and <		1	13	25	19	

It will later be seen that, as a measure of probable distance, the mean of a given group of proper-motions for type *B* corresponds to a larger one of the second type in the ratio of .88 to 1.55, and of type *A* to one of the second type in the ratio of 1.12 to 1.55. Thus a group of stars of type *A* distributed over the entire sky and having mean proper-motion 4″.56 corresponds in distance to a similar group of the second type having $\mu_0'' = 6''.3$. It appears that the stars of types, *A* to *M* are fairly well intermingled within the limits we are considering. The average distance from the sun of type-*F* stars is evidently less than that for any other type. The few *M*-stars average to be somewhat farther from the sun than other types, except *B*. From the facts brought out by the later discussion of type-*B* stars it appears that a space around the sun having a radius equal to the distance represented by $M = 6''$ ($\pi = ''.015\pm$) is almost wholly devoid of these stars. It would appear that within this region the evolution of stars has been going on so long that almost all the *B*-stars that may have once existed there had either moved out, or had developed into older types. This can only be regarded as a suggestion based largely on speculation; yet it seems difficult to put any other interpretation upon the observed facts.

The determining factors in the several values of μ_0'' arise first from the relative mean distance of the totality of stars comprising a particular group. Combined with this effect of distance is another which is concerned with the actual motions themselves, as to whether these may be relatively larger or smaller. Thirdly, we see only that component of the actual motion in space which is projected on the sky, and the proportion of this to the whole may vary with circumstances, as will be shown.

Following out this line of suggestions we may, perhaps, employ μ_0'' for the several subdivisions as a partial guide for determining the limits of the general types to be adopted in this paper. From consideration of the spectra, as well as from the value of μ_0'', it has seemed to me that, for the present purpose, it would be better to include *B*8 and *B*9 with general type-*A*, rather than with *B*. Likewise, when we consider the relation of μ_0'' in the subdivisions of Table 1, the natural point of division between Type *A* and Type *F* seems to be between *A*4 and *A*5. After gaining the experience supplied in the course of this investigation the classification adopted in Table I appears to me satisfactory for the intended purpose.

In preparing the material for use I have adopted as a correction of the centennial proper-motions published in the *Preliminary General Catalogue* the corrections given on page XXVIII of the Introduction (also in *A.J.*, 614, p. 118), viz:

$$\text{For } \mu, \quad +\overset{s}{.}021 \quad -\overset{s}{.}015 \sin\alpha \tan\delta$$
$$\text{For } \mu', \quad -\overset{''}{.}23 \cos\alpha$$

These corrections result from the discussion contained in *A.J.* No. 614 (see especially pp. 117 and 118) concerning precession and motion of the Equinox. These corrections being equally applicable to the apparent motions of all types of stars are important. This correction may amount to almost 0″.6 in an extreme case, as a systematic correction to the centennial proper-motion given in the *P.G.C.* for a single star, or a group of stars. This, in the case of stars of Type *B*, whose mean proper-motion (μ_0'') is only 2″.4, cannot by any means be dismissed as a negligible quantity.

The Methods Employed.

The problem now to be considered is, what are the respective parts played in the mean of the total proper-motions in each spectral type by the effects of apparent parallactic motion and the peculiar motions of the stars themselves. As a means of attacking this problem we should have to know the value of the apparent parallactic motion, *M*, of the stars in each spectral type. Then with the value of $\mu_0'' : M$ we would have an argument for computing the relative mean of the peculiar motions, r_1, for each type under the hypothesis of random-motion (Raymond, *A.J.*, 609).

All our proper-motions had been referred to the Apex of solar motion, so that for each star we had the total proper-motion μ'' and the angle θ which that motion makes with the solar apex. For the position of the solar apex I adopted the value given in *A.J.*, No. 614, p. 112.

$$A = 270^\circ.5 \quad ; \quad D = +34^\circ.3$$

It is evident that, if we resolve the proper-motion into two coordinates:

$$\sigma' = \mu'' \cos\theta \quad ; \quad \text{and } \tau'' = \mu'' \sin\theta,$$

σ' will contain for each star the whole of the parallactic motion, $M \sin\Delta$, (where Δ is the angular distance from each star to the Apex) plus the σ component of the *motus peculiaris* of the star, and τ (often called the "cross-motion") will contain the other coordinate of the *motus peculiaris*, at right angles to the parallactic motion, unaffected by the latter. Under the hypothesis of pure random-motion, the peculiar motions will approximately eliminate from the mean of a large number of values of σ', derived within a given small area of sky, and will leave parallactic motion alone as the resultant, $M \sin\Delta$. The mean τ_0'', on the same hypothesis, when integrated for the entire sphere, would be approximately equal to one-half of the mean of the peculiar motions, *r*, and at the same time would be approximately equal to ρ_0, the mean of the radial motions integrated for the entire sphere. While the mean cross-motions, τ_0', have been derived in the manner described, I have preferred to compute τ'' for each star and obtain the actual mean, τ_0'', for each type, both for the entire sky, and in separate zones for certain types. It appears quite certain that the motions are not purely random in velocity but are sensibly greater in certain directions. Even then we obtain by means of RAYMOND's formulas a value τ_0' corresponding to τ_0'' that appears to be a fair approximation, if the integration is made for the entire sky. With $\tau_0'' : M$ we then obtain a ratio that presents τ_0, the mean velocity of the cross motions, in terms of the sun's motion for a corresponding unit of time.

Preparatory to the computations, the 4,686 available motions had been arranged in zones of the Galaxy, 20° apart; and these zones were subdivided into trapeziums, each containing about 400 square degrees. GOULD's coordinates of the pole of the Galaxy were adopted, viz: $\alpha = 12^h\,41^m\,20^s$; $\delta = +27°\,21'$. It is not unlikely that these could be somewhat improved. Each area furnished the data for one equation of condition for the respective types.

In order to determine the mean velocities for each type of stars, it becomes necessary to determine M, the mean parallactic motion for each type of stars (*i.e.* the motion of the sun in seconds of arc as seen from the mean distance of the stars of that type). We also determine the coordinates, A and D, of the Apex for each type, and the value of τ_0'', mean of all the cross-motions.

In practically working out the quantities required in the solution for different types of stars I have not considered it necessary, in computing the individual values of the cross-motions, τ'', to refer to the special position of the solar Apex found for each type, but to employ for all types the adopted Apex from the General Solution (*A.J.* 614) already quoted. The difference of the mean τ_0'' found in this manner from that which would have resulted from adopting the respective apices, computed for the several types, would have been quite insignificant. Furthermore, it is not wholly certain that the differences of the type-apices from the adopted mean are anything more than uncertainties arising from the nature of the data.

In treating the respective types for special values of A and D, and especially for M, there is no rigorous demand that the motion should be absolutely random in character. It is practically sufficient if we assume that, in a general way, each peculiar motion is on the average balanced by another having an equal velocity in an opposite direction; for if this holds approximately true, it is evident that the peculiar motions will elimate in the mean of a sufficiently large number.

As in *A.J.*, No. 614, leaving out the factor of relative distance of the mean of the stars in the respective areas, and considering X, Y, and Z alone we have the following equations for each star:

From R.A. $X \sin\alpha \quad - Y\cos\alpha \quad = \mu\cos\delta$

From Decl. $X\cos\alpha\sin\delta + Y\sin\alpha\sin\delta - Z\cos\delta = \mu'$

Within each area and for each type we collect all the conditional equations of separate stars into a single mean equation, and from all these mean equations of condition form the normal equations for each type respectively. Here arises a serious difficulty, owing to the small number of stars in most of the type groups. For B, G, and M, respectively, many of the mean conditional equations contain only 2 or 3 stars; and even to have that number it was sometimes necessary to overlook the regular arrangement in trapeziums, and collect the scattered stars from adjoining areas in such a manner, however, that there is seldom a star situated more than 15° distant from the mean of its special area. For each area in the General Solution (*A.J.*, 614) the equation received weight unity. The least number of stars in any one of those areas was 24; only four areas had less than 30 stars (*A.J.*, 612, p. 97). Now, however, in the separate types, the number of stars in a few of the areas is no more than 2 or 3, and there is wide range in the number contained in the separate areas for every type. It becomes necessary to assign relative weights. The adopted formula for computing the weight p, of an equation was:

$$p = \frac{e^2 + \dfrac{(ke)^2}{N}}{e^2 + \dfrac{(ke)^2}{n}}$$

In this, e is the estimated minimum probable error that the absolute term of an equation for any area can have; k is an arbitrary ratio so estimated that ke is supposed to represent the probable error of the absolute term for the equation of a single star; n is the number of stars within a given area, and N is the value of n corresponding to the unit of weight. For the types, B and M, $k = 3$; and for the remaining types $k = 4$. N is taken equal to 6 for type M; to 8 for types B, F, and G; to 12 for type K; and to 16 for type A.

There is here not so much the danger of large nominal probable errors of X, Y, and Z, as of locally anomalous results for proper-motion influencing comparatively large groups of areas. For instance, we may suppose that the sun is rather symmetrically situated among the stars brighter than the sixth magnitude, but the position of the sun relative to such stars restricted to a single type, from the operation of mere chance or otherwise is more liable to be sensibly eccentric; so that the neglect of the distance element in the equations becomes less justified. As always, the stars of larger proper-motion admitted into the computation exert undue weight; but here, in such groups as those of spectral types F, G, and M, this weight is not only troublesomely great, but is also liable to produce anomalous effects owing to the necessarily irregular distribution of these larger motions. We have already excluded all motions greater than 20″, centennial. The establishment of a satisfactory criterion for doing this symmetrically is comparatively easy because of the relatively few stars having proper-motions between 15″ and 20″, say, whose exclusion would be in any serious degree doubtful; but if we reduce the limit to 10″, centennial, then the fixing of the criterion for the exclusion of larger motions implies considerable exactness on the basis of a previous solution of the problems concerning systematic proper-motion (*A.J.*, 612, pp. 97 and 98). Thus: if we are dealing with a group of stars of which the solar parallactic motion (at $A = 90°$) is 4″ then an observed proper-motion of 6″ in the direction of the solar Apex may imply the same, though opposite, velocity of peculiar motion as that of another star at the same distance from the sun having a proper-motion of 14″ toward the Antapex. Or, if we have established the fact that the actual motions of stars tend to be greater in some given direction in space (and its opposite) then we must modify our criterion for rejection of proper-motions to correspond with that fact, and the smaller the motion to which we confine our limit of rejection the more exact our criterion must be known in advance. The anomalous effects of star-drift are more to be feared when the stars are divided into spectral types, both because such drift is very apt to be a phenomenon influencing a single type of stars (the *Taurus* group is an exception) but also because its proportional anomalous effect would be greater on the smaller total of evidence furnished by the comparatively few stars of a single type. There were no rejections for discordances. The probable errors attached to the several determinations of X, Y, and Z, and of their derivatives are apt to be sensibly too small — perhaps by 50 per cent.

The unit of time for τ'', μ'', M, etc., is one century.

In the following sections τ will be expressed in three ways; first as directly determined on the sky in seconds of arc, τ_0''; secondly as a fractional part of M, $\tau'' : M$; third in kilometers per second, τ *km*. The value of τ in the form, $\tau_0'' : M$, is the quantity sought. It is a linear quantity of which the unit of length is the distance which the sun moves in a given unit of time. Its determination is absolutely independent of spectroscopic observations of ρ. In order to make τ and ρ in a measure comparable I reduce $\tau_0'' : M$ to the unit of ρ by supposing the velocity V of the sun's motion in space, the speed representative of M, equal to 20 kilometers per second.

Type B.

The 490 stars of spectral type B were arranged in 42 conditional equations in each coordinate. The separate areas contained from 3 stars each to a maximum of 39 stars. The unit of weight was assigned to 8 stars. We have the following normal equations:

$$
\begin{array}{rrrcr|r}
 & & & & \text{With R} & \text{Without R} \\
 & & & & '' & '' \\
+36.23\,X & -\ \ .18\,Y & -\ 7.50\,Z & = & -\ 5.12 & -\ 5.64 \\
-\ \ .18 & +26.03 & +\ \ .30 & = & -57.64 & -55.05 \\
-\ 7.50 & +\ \ .30 & +29.29 & = & +43.82 & +43.48
\end{array}
$$

The mean μ_0'' for these stars is 2″.40. The *p.e.* of the unit of weight is ±″.55; and is small because the proper-motion is so largely parallactic, the anomalies of *motus peculiaris* being necessarily small. The solution gives.

$$
\begin{array}{rcll|rcll}
X & = & +0''.17 & \pm''.09 & A & = & 274°.4 & \pm 2°.4 \\
Y & = & -2.23 & \pm.11 & D & = & +34.9 & \pm 2.0 \\
Z & = & +1.56 & \pm.10 & M & = & 2''.73 & \pm''.10
\end{array}
$$

There is nothing here to indicate that the 490 stars of type B have any pronounced systematic motion relative to the stars in general. The distribution of the stars of B type over the celestial sphere is far from uniform in different Galactic longitudes; only 42 of the 490 stars here considered have latitudes greater than 30° (see Table IV, later on). Consequently the determination of the peculiar motion from $\mu_0'' : M = 0.88$, through Raymond's tables, *A.J.* 609, is theoretically very imperfect, aside from the question whether the motions can be assumed to be at random. But with that argument, $\mu_0 : M = 0.88$ we have: mean r_1 (peculiar motion) $= .56\ M$; $\tau_0' = .28\ M$, as if $\tau_0'' = .''76$.

The direct computation of τ_0'', adopting the Apex of solar-motion from the General Solution (*A.J.* 614) gives:

From 279 motions (when $\theta = 0°$ to $180°$), $\tau_0'' = .''86$
From 211 motions (when $\theta = 180°$ to $360°$), $\tau_0'' = ''86$

The mean value of τ_0'' is ″.86. We then have $\tau_0'' : M = .315$, and τ km. = 6.3 km. per second.

On the hypothesis of random motion we should have the radial velocity, ρ_0, equal to τ_0 and hence equal to 6.3 km. This is exactly the mean velocity, ρ_0, assigned to 61 stars of type B by Frost and Kapteyn (*Astroph. Jour.*, Vol. 32, p. 89) Campbell finds from 141 stars of type B, $\rho_0 = 9.0$ km (*Ast. Soc. Pac.*, Vol. 22, No. 134, p. 238). This includes stars of spectral type $B8$ and $B9$ which I include in the A type. The direct mean value of ρ_0 was first computed by Kapteyn and Frost on the assumption that V is 23.3 km., giving $\rho_0 = 6.7$ km. for 61 stars of type B. Adopting separate values of V (−18.38 km. and −28.38 km.) for Apex and Antapex respectively they find $\rho_0 = 5.9$ km. The mean of these two results 6.3 km. is then adopted by them.

Frost's 61 values of ρ collected in his table of B stars (*Ap. J.*, Vol. 32, pp. 84 and 85) include 10 stars of the subdivisions *B8* and *B9* which I have included in type-group *A*. In view of Campbell's recent result for the solar velocity, 17.8 km. (*Ast. Soc. Pac.*, No. 134) it does not seem advisable to estimate V higher than 20 km. Excluding the 10 stars of subdivisions $B8$ and $B9$, and putting $V = 20$ km., I derive from FROST's table for 51 stars of the B type, $\rho_0 = 6.8$ km., which I adopt. The agreement of this result with the value of τ km. computed from the cross-motions is still remarkably close.

It is extremely probable that between latitudes 0° and 30° we see a projection of τ_0'' which is less than half the mean peculiar motion, and that ρ_0 in these limits is more than half. As will be seen under type A the mean projection of τ_0'' below 30° of latitude requires to be multiplied by about 1.05 in order to reduce it to what would be the case if the stars were well distributed over the entire sphere, so that the value of τ km. reduced to the same standard as later types would have been 6.3 km. ×1.05 = 6.6 km. At my request my assistant, Mr RAYMOND, has found the ratio of mean τ_0 and mean ρ, at various latitudes, on the hypothesis that the schematic arrangement of the peculiar motions in space constitutes a roughly ellipsoidal figure with the two minor axes approximately equal and bearing the ratio of 4 to 7 to the major axis supposed to be parallel to the plane of the Milky Way. This is only tentative at present, but results in the ratio of ρ_0 to τ_0 between latitudes 0° to 30° of approximately 1.15. Therefore if we assume $\tau_0 = 6.3$ km. as it results from the present discussion, the predicted value of ρ_0 for B stars should be 7.2 km. Upon this hypothesis the seeming discordances on the whole are reduced, and are now not unreasonably large. This subject is deserving of a greater accumulation of data and of further investigation.

The determination of ρ for types B and A is beset with difficulties. The spectral lines are diffuse; it is conceivable that small residual systematic errors of measurements may have crept into the determination of the mean values of ρ_0; perhaps there are theoretical uncertainties in interpretation of the spectra; the prevalence among types A and B of spectroscopic binaries, now imperfectly determined, or even undetected, undoubtedly tend to increase the probable error of the results for ρ.

Since there are some indications that the situation of the sun among stars of the B type may be sensibly eccentric, I have attempted a solution for X, Y, and Z, in which the relative distances of the 42 groups are roughly taken into account through the observed parallaxes, $\sqrt{\mu^2 \cos^2\delta + \mu'^2}$, combined with mean μ_0'' for groups that are near the apices. This course is not by any means rigorous and by some might be regarded as involving unwarrantable assumptions. However, I give it for what it may be worth. The normal equations are the same as before, except that the absolute terms are those given under "with R" (p. 191) instead of those under "without R." employed in the foregoing. The solution leads to the following values of the unknowns A and D.

$$\text{R.A.} = 274^\circ.1 \quad ; \quad \text{Decl.} = +35^\circ.9$$

agreeing well with the solution, "without R."

It is well, also, to notice that when the velocity of stars is very small in the mean, and the probable error of determination of individual values is large relatively to mean τ or ρ the observed values of those quantities will be in excess of the true values. I should estimate this excess to be, in the case of τ_B five to ten per cent.

The arrangement of B stars on the sky seems to have somewhat of a clustering tendency, where they are most thickly found (BENJAMIN BOSS in $A.J.$ 620, p. 164 and 166). This tendency seems to be specially noticeable along the Milky Way between 6^h and 19^h. But in order to examine this matter satisfactorily we need to know the types to a much fainter limit of magnitude.

Type A.

There were 1,647 stars of the spectral types $B8$ to $A4$ inclusive which are here designated as type A. These were assembled in 110 areas and partial areas. There are less than 8 stars in each of 14 areas (minimum of 4), one area had 35 stars and the mean is 15. On the whole this affords a fair chance of good elimination of the peculiar motion in the greater part of the equations of condition. Weight unity was assigned to an equation based on 16 stars. There are 110 equations furnished in each coordinate.

The resulting normal equations are:

$$\begin{array}{rrrcr}
+67.55\,X & +\;\;.17\,Y & -\;2.21\,Z & = & -\;\;\overset{''}{4}.68 \\
+\;\;.17 & +62.86 & -\;\;.28 & = & -226.15 \\
-\;2.21 & -\;\;.28 & +65.51 & = & +127.58
\end{array}$$

The probable error of the unit of weight is ±″.59. The results for the unknowns and their derivatives are:

$$\begin{array}{rcl|rcl}
X & = & +\;\overset{''}{.}003 \pm \overset{''}{.}072 & A & = & 270\overset{\circ}{.}0 \;\; \pm 1\overset{\circ}{.}3 \\
Y & = & -3.589 \pm .075 & D & = & +\;28.3 \;\; \pm 1.1 \\
Z & = & +1.932 \pm .073 & M & = & 4''.08 \pm ''.08
\end{array}$$

The mean value of μ_0'' is 4″.56 and hence with the argument, $\mu_0'' : M = 1.12$, mean $r_1 = 1.06M$; $\tau_0' = .53\,M = 2''.17$. But computing τ_0'' directly from the actual individual cross-motions and with the adopted position of the solar Apex ($A.J.$ 614) we have:

From 867 values ($\theta = \;\;0^\circ$ to 180°), $\tau_0'' = 2''.06$
From 580 values ($\theta = 180^\circ$ to 360°), $\tau_0'' = 2''.09$

Adopted τ_0'' is 2″.07 in fair agreement with the result derived from RAYMOND's formulas (2″.17) based on the hypothesis of random motions. Hence, $\tau_0'' : M = .508$, and τ km. = 10.2 km. From CAMPBELL's value of ρ_0 for 133 A stars, we have $\rho_0 = 9.9$ km. (*Pub. A.S.P.*, Vol. 22, p. 238). Professor FROST has kindly communicated to me copy of a paper read by him at the November (1910) meeting of the National Academy of Sciences, in which he finds from 33 stars of type *A* $\rho_0 = 10.1$ km. Taking the mean of the components of a double star, and assuming $V = 20$ km., I find from 32 stars of type *A* in FROST'S list, $\rho_0 = 10.4$ km. The agreement of τ_0'' and ρ_0 from various scources seems to be very satisfactory. Between the types *B* and *A* the acceleration in $\tau_0'' : M$ is not very great but I should estimate that it is considerably more than 30 per cent., at the least.

Type A by Zones.

Inspection served at once to indicate that the velocity indicated by the projected motions, τ_0'', of *A* stars is probably greater in high than in low latitudes. Though the material is scanty I decided to determine *A*, *D*, and *M* for each of three galactic zones with the following results indicated in succinct form:

Zones	No. Stars	μ_0''	*A*	*D*	*M*	τ_0''	$\tau_0'' : M$
° °		"	° °	° °	"	"	
+10 to −10	422	3.56	275.3 ± 2.6	+29.7 ± 2.7	3.84	1.53	.40
±10 to ±30	620	4.46	268.7 ± 1.7	+27.5 ± 1.8	4.12	1.92	.47
±30 to ±90	605	5.37	266.9 ± 2.0	+29.0 ± 1.5	4.20	2.60	.62

Progressive increase in the value of *M* though shown is not very decisively indicated. I should have anticipated that *M* for the first zone would have been less and for the third greater than the present values. On the other hand the increase of τ_0'' with latitude is striking. This can come from three sources.

1. If the mean linear velocities of stars of this type are the same all over the sky we should still have a variation of τ_0'' proportional to *M*. This, of course, does not appear in $\tau_0'' : M$.

2. If we see a greater proportion of the peculiar motions projected on the sky in the higher than in the lower latitudes we would have an apparent increase of $\tau_0'' : M$, even without increase in linear velocity in space.

3. Increase in $\tau_0'' : M$ might be due, in part, to an actual difference of mean velocity for the stars in the respective zones.

It seems probable that, apart from that which may be due to unavoidable probable error, the apparent increase of τ_0'' with latitude may be the cumulative effect of all three causes.

The value of *M* increases with latitude, and taking this into account, the ratio of $\tau_0'' : M$ between the first and last zone has been somewhat decreased, and judging from analogy furnished by cases later on in this paper, the casual errors in the determination of *M* for stars of type *A* are probably in the direction to mininize increase of *M* with latitude.

It appears likely that there is a tendency of the actual peculiar motions to have greater velocities in a direction parallel to the plane of the Galaxy and also near the direction of longitude 167° and 347° in that plane. If that be the case, the mean of the projections of the peculiar motions on the plane of the sky might vary greatly in different localities, and it seems that, in the mean, these projections would increase with increasing latitude. It appears from my examinations that this effect of greater extension of the peculiar motions of the stars in the general directions already stated (corresponding to the position of EDDINGTON'S Vertex, R.A., 94°.2, Decl. +11°.9, *Month. Not.* Vol. 71. p. 35) probably exists, and requires further attention hereafter. This gives rise to schematic diagrams of proper-motions whose boundaries are not circles, but ellipses. These ellipses may be imagined as the projections on the sky of ellipsoidal figures in space, of which the ratio of the long axis to the two roughly equal minor axes I now estimate as somewhere about 7 : 4. This corresponds to the suggestion of SCHWARZSCHILD (*Nach. der Kön. Ges. d. Wiss. zu Gottingen*, 1907, *Heft* 5, pp. 614-630, and 1908, *Heft* 2, p. 191). At my suggestion, my assistant, Mr. RAYMOND, has determined approximately, under these conditions, the ratio of the mean of the projections τ_0'' upon the sky for different areas classified in latitude and longitude. Taking $\tau_0'' : M$ for the entire sphere as the unit, I determine from the computation described the ratio in each zone of $\tau_0'' : M$ in that zone to the similar quantity for the entire sphere. This is given under "I." Under "II" are the multipliers to be used with the special values of $\tau_0'' : M$ in the respective zones to reduce them to the corresponding value for the entire sphere. Under "$\tau_0'' : M$ (Corr'd.)" is the product of the corresponding solution-values in the respective zones by the factors under "II."

Zone	I	II	$\tau_0'' : M$ (corr'd)
° °			
+10 to −10	.941	1.063	.43
±10 to ±30	.955	1.047	.49
±30 to ±90	1.051	.952	.59

The discrepancy between the value of $\tau''_0 : M$ between the first two zones compared with the last is materially reduced, by reducing the mean zonal projections of τ'' on the sky to the mean for the entire sphere. If this cause of difference were the only thing to be accounted for, then the values of $\tau_0'' : M$ (corr'd.) should agree within the probable error of determination. It appears that the zonal differences are still too great to be easily attributed to probable error alone.

We will then proceed to consider the third element. There is but little doubt but that this has a small but sensible effect in making the mean velocity of the *A* type stars a minimum in the Milky Way and a maximum at the Galactic poles. Tables IV and V, later on in this article, show the very great preponderance of *B* stars in low latitudes. They are very scarce in high latitudes. In type *A* we have a suggestion of the same phenomenon, but in a much less degree. There are approximately half as many *A* stars in areal density at the Galactic poles as at the Galactic equator. This relation varies quite regularly throughout the types, in the supposed order of evolution, and is especially striking in the earlier types. This is shown in the following table in which the *A* type is subdivided, and the number of each of these subdivisions of spectral type contained in each of the three zones is enumerated.

TYPE *A* SUBDIVIDED.

Zone	B_8 and B_9	A	A_1 to A_4
°			
+10 to −10	77	282	63
±10 to ±30	81	443	96
±30 to ±90	59	430	116

The next table shows the percentage of each of the sub-types contained in each zone.

TYPE *A* SUBDIVISIONS. PERCENTAGE IN EACH ZONE.

Zone	B_8 and B_9	A	A_1 to A_4
° °			
+10 to −10	18	67	15
±10 to ±30	13	72	15
±30 to ±90	10	71	19

Thus the stars of sub-type, A_1 to A_4 relative to those of B_8 to B_9 are, proportionally to the whole, in the third zone (polar) more than twice as numerous as they are in the Milky Way. That is to say of the swifter moving type A_1 to A_4 there are relatively more in the polar zone than of the same type in the first zone, and the reverse for the slow-moving type B_8 to B_9. If we could subdivide plain *A* into groups, according to age, we should probably find the sub-type representing younger stars relatively more numerously represented in the Milky Way. I estimate that the effects just described result in a mean motion of *A* stars in latitudes less than 30° from .4 km. to .6 km. slower than the mean for *A* stars above latitude 30°. This helps to diminish the discrepancy between zonal values of $\tau_0'' : M$ for stars of type *A*.

In order to make it clearer what has been accomplished by allowing for the hypothetical distribution in space of motions as to velocities, as well as for the estimated effect of a larger relative proportion of the younger stars of type *A* in latitudes less than 30° than in latitudes above 30°, we have the following comparison:

Zone	$\tau_0'' : M$ Obs.	$\tau_0'' : M$ Adj.	.51−Adj.
+10 to −10	.40	.45	+.06
±10 to ±30	.47	.51	.00
±30 to ±90	.62	.56	−.05

Under "Obs." are given $\tau_0'' : M$ as determined originally in the zonal solutions; under Adj. the same when adjusted as in the foregoing to be comparable with the value of $\tau_0'' : M$ determined for the solution for all the 1,647 *A* stars, distributed over the entire sky. This value is .51 The adjustment leaves much to be desired in its basis; though there are certainly effects due to these two causes approximately like the ones found. The discrepancies under .51 − "Adj." are rather large to be attributed to probable error alone, but not impossibly so.

It is necessary to bear in mind that the motions peculiar to the stars themselves vary greatly even among those of exactly the same spectral type. Those originating comparatively near the Galactic plane in which the sun now is would have had a tendency, on the whole, to increase in latitude as they approached the present position of the sun. This tendency would evidently have been greater for those stars that have the greatest velocities; so that the general result, on the basis of a supposed comparative sparseness of stars originating at greater distances from the Galactic plane, would have been a selective action tending to make the mean motions of a given spectral type, on the whole, larger in high than in lower latitudes. The extent of this action would depend upon the comparative thinness of the stratum near the sun's present Galactic plane from which an excess of stars might be conjectured to have originated. At the same time it is not required that this preponderance in place of origin should have been very striking. Possibly some traces of that effect may be recognized in the "Adjusted" values of $\tau_0'' : M$ in the last preceding table. This, however, is offered as a mere speculation, suggested by a variety of indications. Apparently, at present, it cannot easily be raised to the dignity of a working hypothesis.

The position of the solar Apex, computed from the motions of stars in type *A*, differs from the adopted Apex, resting on the General Solution (*A.J.* 614), by 0°.5 in R.A. and 6°.0 in declination. Increasing the nominal probable errors by 50 per cent., a reasonable supposition, we might set down the probable differences at ±2°.0 and ±1°.7 in R.A. and Decl. respectively. The preponderance of weight is that there is a real difference. In my opinion, this difference is not large enough to indicate anything more than the cumulative effects of anomalous star-drift, too small, in individual instances, to attract sure identification.

The foregoing results for the motions of stars in types, *B* and *A*, almost fully explain the phenomenon alluded to at the beginning of this paper in relation to the value of $\mu_0'' : M$, which in the solutions by zones of latitude (*A.J.* 614) showed this quantity to increase with latitude. In other words the relative proportion of stars of types *A* and *B*, having peculiar motions much smaller than those of later types (as will be shown) is much greater near the Milky Way than in higher latitudes. There is also an effect arising from the smaller projections of those motions on the plane of the sky for stars near the Milky Way.

Type F.

The fact that the mean proper-motion, $\mu_0'' = 7''.71$, of 656 stars of type F (A_5 to F_9) is notably greater (when stars of proper-motions less than 20″ are considered as here) than for any other type lends special interest to that group. The material was divided into 103 areas. The mean number of stars in each area is 6 or 7. Three areas have only two stars each, ten areas have three stars each, and the maximum number in any one area is 16. Unit of weight was assigned to 8 observations. These 103 equations in each coordinate led to the following normal equations:

$$\begin{array}{rrrcr} +55.83X & +\ \ .43\ Y & -\ \ .75\ Z & = & -\ 21''.29 \\ +\ \ .43 & +53.86 & +\ \ .50 & = & +234.24 \\ -\ \ .75 & +\ \ .50 & +52.82 & & -124.51 \end{array}$$

The probable error of the unit of weight is $\pm 1''.32$,—large because the motions are large and stars in many areas few. Following are the deduced values of X, Y, Z and their derivatives:

$$\begin{array}{rcl|rcl} X & = & -\ \ .32'' \pm .18'' & A & = & 265°.9\ \ \pm 2°.4 \\ Y & = & -4.37 \pm .18 & D & = & +28.7\ \ \pm 2.1 \\ Z & = & +2.39 \pm .18 & M & = & 4''.99 \pm ''.18 \end{array}$$

With $\mu_0'' : M = 1.54$, on the hypothesis of random motion we have: $r_1 = 1.73 \times M$. Hence $\tau' = .86 \times M = 4''.32$ But for the cross-motions computed directly we have:

From 348 motions ($\theta =$ 0° to 180°) $\tau_0'' = 3''.96$
From 308 motions ($\theta =$ 180° to 360°) $\tau_0'' = 4''.11$

Hence $\tau_0'' = 4''.03$; $\tau_0'' : M = .81$; τ km. $\doteq$ 16.2 km. It will be found, hereafter, that the velocity has substantially reached its full maximum in the F stars, after which it does not certainly experience any modification greater than can easily be attributed to accidental causes and to the probable error of its determination. From 159 stars of type F Campbell finds : $\rho_0 = 13.9$ km.; this, too, when stars of spectral type, A^5 to A^8 have not been included by him in type F, as has been the case in this paper, in computing τ ; so that the discrepancy between ρ_0 and τ_0 would probably have been greater if Campbell had included the subdivisions $A5$ and $A8$. I should estimate that the probable error of τ km. for F-stars, aside from the error of the assumed value of M in kilometers, might be ±1.0 km.; but with a like probable error of ρ the observed difference of the two does not seem incompatible with equality of τ and ρ. If Campbell's values happen to be taken mainly from stars in high latitudes a part of the difference might be attributable to that fact.

Stars of the spectral type, F, show some analogy to those of A in the small value of D, making the difference from D in type K larger than is readily compatible with the combined probable errors, but not impossibly so.

The value of M, 4″.99, makes this type F, as a group, nearest neighbors of the sun so far as can be determined from stars having proper-motions less than 20″. So far as can be judged from Table II (*ante*) this statement in regard to type F holds good for stars with larger proper-motions.

Type G.

This group comprises 444 stars having μ_0'' equal to $5''.24$. Great accuracy cannot be anticipated in the determination of A, D, and M for this group. There were constructed 81 equations of condition in each coordinate from as many areas, an average of only 5 or 6 stars in an area. Three equations were founded on only two stars, ten on three stars only, and the largest number for any one was 12. The unit of weight was assigned to an equation founded on 8 stars. The normal equations are:

$$\begin{array}{rrrcr} +38.99\ X & +\ 1.40\ Y & -\ \ .32\ Z & = & -20''.51 \\ +\ 1.40 & +36.07 & -\ \ .55 & = & -83.49 \\ -\ \ .32 & -\ \ .55 & +40.76 & = & +86.85 \end{array}$$

The probable error of the unit of weight was $\pm 1''.15$, somewhat less than in the preceding F type, as should be the case with the smaller value of μ_0'', $5''.24$. The solution gives:

$$\begin{array}{rcl|rcl} X & = & -\ \ .43'' \pm .18'' & A & = & 259°.3 \pm 4°.7 \\ Y & = & -2.27 \pm .19 & D & = & +42.3 \pm 3.5 \\ Z & = & +2.10 \pm .18 & M & = & 3''.12 \pm\ .19'' \end{array}$$

There seems to be a larger proportion of stars of this type situated at a comparatively great distance from the sun than for any of the types treated in the foregoing. At the same time reference to Table II (*ante*) shows that space is rich in this type of stars in the immediate neighborhood of the sun. Stars having proper-motions larger than 80″ number 25 in Table II against 33 for all other types combined. On the random hypothesis (*A.J.* 609), we have with the argument $\mu_0'' : M = 1.68$: mean $r_1 = 1.93\ M$; $\tau' = .96 \times M = 3''.00$. Computing the cross-motion directly we have:

From 228 stars ($\theta =$ 0° to 180°), $\tau_0'' = 2''.88$
From 216 stars ($\theta =$ 180° to 360°), $\tau_0'' = 2''.89$

The mean adopted τ_0'' is $2''.89$; whence $\tau_0'' : M = .93$; τ km. = 18.6 km. Aside from the uncertainty of M in kilometers per second the probable error of τ km. must be nearly ± 1.5 km.

Campbell, from 529 stars of types G and K obtains: $\rho_0 = 15.2$ km. This latter value would be comparable with the means by weight of the values of τ km. from types, G and K, which is about 16.0 km., as will be seen under type *K* later. The agreement between the cross-motions and radial motions of those two types is, therefore, good.

The discordance of the position of the solar apex from stars of type *G* compared with those of *A* and *F* is quite pronounced; and there is probably a real difference in spite of the large probable errors, undoubtedly much larger than those given by the computations.

Type K.

This type contains 1,227 stars with $\mu_0'' = 5''.74$. The conditions for determining the coordinates for this type are much more favorable than for any other group except *A*. There were 112 areas and as many equations of condition for each coordinate. The fewest number of stars in any one area is three; only ten areas have less than 6 stars; and 25 is the largest number of stars in any one area. The mean is 11 stars, and the unit of weight rests on 12 stars. Following are the normal equations:

$$\begin{array}{rrrl} +69.64\,X & +\ 1.70\,Y & -\ .07Z & = +\ \overset{''}{14.80} \\ +\ 1.70 & +70.01 & +\ .55 & = -211.70 \\ -\ .07 & +\ .55 & +67.45 & = -175.01 \end{array}$$

The probable error of the unit of weight is $\pm''.98$. The values of the unknowns and of their derivatives are:

$$\begin{array}{ll|ll} X = & +\overset{''}{.29} \pm \overset{''}{.12} & A = & \overset{\circ}{275.}\ 4 \pm \overset{\circ}{2.2} \\ Y = & -3.05 \pm .12 & D = & +40.31 \pm 1.7 \\ Z = & +2.62 \pm .12 & M = & \overset{''}{4.03} \pm \overset{''}{.12} \end{array}$$

The values of *A* for types *G* and *K* respectively are very discordant, probably due, in large part, to type *G*. The value of *D* for types *G* and *K* agree well, and both are very discordant from the declination of the Apex worked out for types *A* and *F*. There can be but little doubt that there is a sensible, though relatively small general shifting of the stars of types *G* and *K*, relative to those of *A* and *F*. On the hypothesis of random-motion we have from RAYMOND'S tables (*A.J.* 609) with the argument $\mu_0'' : M = 1.42$; mean $r_1 = M \times 1.55$; $\tau' = .78 \times M = 3''.13$. Computing the cross-motions directly we have:

From 627 motions ($\theta = 0°$ to $180°$), $\tau_0'' = 2''.94$
From 600 motions ($\theta = 180°$ to $360°$), $\tau_0'' = 3''.15$

Adopted mean from 1,227 stars of type $K : \tau_0'' = 3''.04$. Hence $\tau_0'' : M = .754$; τ km. = 15.1 km. For type *G* we found: τ km. = 18.6 km., and combining this with τ km. for type *K* as just found with relative weights 1 and 3, respectively, would give τ km. = 16.0 km. for the combination of *G* and *K*, as against $\rho_0 = 15.2$ km. by CAMPBELL. The agreement is very good, and would be perfect if we assume $V = 19$ km. The positive and negative cross-motions are rather discordant; but their mean is largely compensating and cannot be very different from what it would have been if θ and μ'' had been referred to the Apex derived from type *K*.

Type K in Galactic Zones.

Of the 1,227 stars of type *K*, 237 only are contained in the Galactic zone between the parallels of latitude +10° to −10°; so that the results deduced from the motions of *K* stars for that zone have very small weight. The following statement contains the principal results from my computations upon these three Galactic zones. In the third line are given the results from the condensation of the first two zones into one.

Zones	No. Stars	μ_0''	*A*	*D*	*M*	τ_0''	$\tau_0'' : M$
° °		"	° °	° °	" "	"	
+10 to −10	237	4.51	271.7 ± 6.6	+45.2 ±5.7	3.18 ±.31	2.58	.81
±10 to ±30	410	5.49	271.9 ± 3.4	+35.3 ±3.2	3.91 ±.22	2.80	.71
0 to ±30	647	5.13	272.0 ± 3.0	+38.2 ±2.8	3.67 ±.18	2.72	.74
±30 to ±90	580	6.42	277.0 ± 3.6	+41.9 ±2.2	4.29 ±.16	3.40	.79

It does not appear that any profitable conclusion can be drawn for the zone +10° to −10° considered separately. The values of $\tau_0'' : M$, in order to be made comparable with the mean value of that quantity when taken from stars spread over the entire sky need a correction on account of the greater extension of motions around the line; $l = 167°$, $b = 0°$ to $l = 347°$, $b = 0°$, as explained under type *A*. The projection τ_0'', for the three zones increases with latitude. The factors necessary to reduce these to that value which corresponds to the entire sky is given on p. 27. Thus the values of $\tau_0'' : M$ as adjusted would be as follows:

	$\tau_0'' : M$	
°	Obs.	Adj.
0 to ±30	.74	.78
±30 to ±90	.79	.75

There is here excellent agreement in the two adjusted values and, in their mean, with the value .754 derived for *K* stars when the mean solution is made for the entire sky.

Type M.

The 222 stars of type *M* have been arranged in 51 areas much in the same manner as for type *B*. These areas contain from one to ten stars each. The unit of weight is assigned to an equation containing only 5 or 6 stars. The probable errors of the results will necessarily be large; yet the results ought to have value as an indication. Following are the normal equations:

$$\begin{array}{rrrl} +26.61\,X & +\ .40\,Y & +\ .85\,Z & = +\ \overset{''}{5.01} \\ +\ .40 & +28.11 & +\ 1.19 & = -69.12 \\ +\ .85 & +\ 1.19 & +25.43 & = +49.52 \end{array}$$

The probable error of the unit of weight is $\pm 1''.18$. This is rather unexpectedly small, but is so partly on account of the low value of $\mu_0'' = 4''.99$. The deduced values of the unknowns and of their derivatives are as follows:

$$\begin{array}{ll|lll} & {}'' & & {}^\circ & {}^\circ \\ X & +\ .16 \pm .23 & A = & 273.6 & \pm 5.2 \\ Y & -2.56 \pm .22 & D = & 38.8 & \pm 4.1 \\ Z & +2.06 \pm .23 & M = & 3''.29 & \pm ''.23 \end{array}$$

On the random-hypothesis we have with the argument, $\mu_0'' : M = 1.52$: mean $r_1 = 1.69\ M$; $\tau_0' = .84 \times M = 2''.78$. This is not very different from the actually computed mean value of the 222 cross-motions, viz.:

From 125 motions ($\theta =$ 0° to 180°), $\tau_0'' = 2''.85$
From 97 motions ($\theta =$ 180° to 360°), $\tau_0'' = 2''.78$

Adopted value from the whole of the 222 stars is, $\tau_0'' = 2''.82$. Hence, $\tau_0'' : M = .86$; τ km. = 17.1 km. CAMPBELL finds from 72 stars of type M, $\rho_0 = 16.6$ km. (*A.S.P.* Vol. 22, p. 238), in practically perfect agreement with τ km., though the two values must be affected with probable errors of more than ±1.0 km. or ±1.5 km.—especially for τ. I conclude that there is really not very much difference in the mean velocities for the four types *F*, *G*, *K*, and *M*, and, therefore, as a final test I consolidate the data for those four types into one solution.

Solutions for Combined Types F, G, K and M.

In the four types *F* to *M* we have 2,549 stars in all. The resulting normal equations are:

$$\begin{array}{rrrcr} +147.08\,X & +\ \ 3.25\,Y & -\ \ \ .13\,Z & = & -\ \ 8''.35 \\ +\ \ 3.25 & +145.27 & +\ \ 1.25 & = & -449.29 \\ -\ \ \ .13 & +\ \ 1.24 & +143.70 & = & +340.85 \end{array}$$

The probable error of the unit of weight is $\pm ''.98$, the weights all having been reduced to the standard of *K*. The mean value of μ_0'' is $6''.09$. The values of the unknowns and their derivatives are:

$$\begin{array}{lll|lll} & {}'' & {}'' & & {}^\circ & {}^\circ \\ X = & +\ .01 & \pm .08 & A = & 270.3 & \pm 1.5 \\ Y = & -3.11 & \pm .08 & D = & 37.6 & \pm 1.2 \\ Z = & +2.40 & \pm .08 & M = & 3''.93 & \pm ''.08 \end{array}$$

On the random hypothesis with the argument, $\mu_0'' : M = 1.55$, we have: mean $r_1 = 1.738 \times M$; $\tau_0' = .87 \times M = 3''.42$. Computing the cross-motions directly from the proper-motions we obtain, $\tau_0'' = 3''.25$; whence $\tau_0'' : M = .828$; and τ km. = 16.6 km. This may be adopted as the result for stars of the second and third types to be compared with 6.3 km. for the *B* type (hypothetically amended to 6.6 km. referred to a general mean for the sphere, p. 192) and 10.2 km. for stars of the *A* type.

This combination was also solved in Galactic zones as for types, *A* and *K*. Following is a summary of results:

Zones	No. Stars	μ_0''	A	D	M	$\tau_0'':M$	
						Obs.	Adj.
° °		''	° °	° °	'' ''		
+10 to −10	521	4.65	266.7 ± 3.8	+38.4 ± 3.7	3.25 ± .21	.80	.85
±10 to ±30	819	5.90	269.0 ± 2.2	±35.2 ± 2.1	4.14 ± .15	.74	.77
±30 to ±90	1209	6.80	271.5 ± 2.6	±38.5 ± 1.7	4.00 ± .11	.92	.88

The deviations of the adjusted values of $\tau_0'' : M$ in the last column from the value, $\tau_0'' = .83$, previously deduced from stars distributed all over the sky, with which these three are approximately comparable, are −.02 +.06 and −.05, deviations which are probably no larger than the character and amount of data should lead us to expect.

In the foregoing computations and analyses I have been efficiently assisted by Mr. B. BOSS and Mr. H. RAYMOND, as well as by other members of the computing staff of the Department of Meridian Astronometry at Albany of the CARNEGIE Institution of Washington.

Summary of Velocities by Types.

We may now bring under one view, in Table III, the results for mean distances and velocities of stars of each type. $\tau_0'' : M$ has been converted into kilometers, with the solar velocity, V equal to 20 kilometers per second. By the help of the column, $\tau_0'' : M$, which is the mean velocity of τ in terms of the sun's motion and depends solely upon the proper-motions, τ km. can be computed by the adoption of any value of V that may be preferred. In the last line of Table III, results are given that are based upon a discussion of stars of types *F*, *G*, *K* and *M* jointly, in order to give ready comparison with results for *B* and *A*. For convenient comparison, the several values of ρ_0 derived by CAMPBELL and FROST appear in the last column.

Except for CAMPBELL's value of ρ_0 for *B* stars, in which he differs widely from FROST and also from the value of τ_0 in this paper, the agreement of the last two columns of Table III seems to be quite as good as the material would lead us to expect. Though τ_0 is not necessarily equal to ρ_0, even when the entire sphere is integrated, we must conclude that, in all probability, the distribution, though probably not purely random in velocity, is nearly random in direction and approximately *symmetrical* in distance, in which case when taken over the entire sphere there should be good approximations to each other of the mean values of τ_0 and ρ for any one type. At the same time it is quite certain that projections on the sky in the form of τ'' vary in proportional amount with position in the sky. In general when τ'' is proportionally small ρ is proportionally great. The general effect is for $\tau_0'' : M$ to be a minimum in the Milky Way and for ρ_0 to be a maximum there. Mr. RAYMOND, of this observatory, has

TABLE III. DISTANCES AND VELOCITIES FOR THE SEVERAL TYPES.

Type	No. Stars	M	τ_0''	$\tau_0'' : M$	τ_0 km	ρ_0 km.	
		″	″				
B	490	2.73	.86	.315	6.3*	9.0 6.3	CAMPBELL† FROST‡
A	1647	4.08	2.07	.508	10.2	9.9 10.1	CAMPBELL FROST**
F	656	4.99	4.03	.81	16.2	13.9	CAMPBELL
G	444	3.12	2.89	.93	18.6	15.2	CAMPBELL
K	1227	4.03	3.04	.754	15.1		
M	222	3.29	2.82	.86	17.1	16.6	CAMPBELL
F,G,K,M	2549	3.93	3.25	.828	16.6		

provisionally worked out these relations as already stated (*ante* p. 193), but publication is deferred until more exact data for the constants have been employed. But with the present provisional tables, and without critical treatment, I have found under the discussion for type *B* that τ_0 when reduced to the mean projection for the entire sphere is 6.6 km, instead of the value 6.3 km. which appears in Table III. Likewise CAMPBELL's determinations of ρ, if determined on *B*-stars having roughly the same distribution as the *B*-stars of this paper, would need a reduction of about 9 per cent. in order to make his ρ_0 correspond to a mean value for the entire sphere. Thus we should have instead of his 9.0 km., as given in Table III, approximately 8.3 km. in order to make it comparable with the corrected value of τ_0, 6.6 km. In like manner FROST's ρ_0 (as revised by me) would be reduced from 6.8 km. to about 6.2 km. CAMPBELL's value of ρ_0 for *B* stars would probably be still further reduced if subdivisions B_8 and B_9 were excluded. The matter needs further and more strict examination.

Velocity of the Sun.

The value, 20 km. per sec., for V, the velocity of solar motion, seems now to be of greater probable accuracy as an estimate of that quantity than the value 24 km. deduced in my former paper, *A.J.* No. 614, p. 119. This is still decidedly larger than the value, 17.8 km., recently deduced by Professor CAMPBELL from his 1047 measures of ρ secured at the two stations of the Lick Observatory (*Pub. A.S.P.*, Vol. 22, p. 237) since the value is based upon measures distributed over the entire sky, it seems entitled to greater confidence than any determination of V by that method which has hitherto been made. But it is subject to some systematic uncertainties to such an extent that it is perhaps conceivable that an error in it as great as 2 km. is admissible. If we *assume* that mean τ_0, and mean ρ_0 for the entire sky should be equal, then the value 19 km. for V would reconcile the type-values of τ_0 and ρ_0 somewhat better than does the 20 km. here employed.

On the other hand, the adoption of 20 km. seems to put something of a strain on the requirements of the large number of fairly reliable measures of annual parallax now available for an independent evaluation of V from these combined with the proper-motions. Nevertheless, after a careful consideration of the data, I am inclined to think that 20 km. is not entirely irreconcilable with what the available measures of annual parallax require, in view of the hypothetical uncertainties involved in a determination by that method. After all, the proportional difference between 20 km. and 24.5 km., which the annual parallaxes seemed to require, in view of the minuteness of the measured quantities concerned, and theoretical difficulties involved in that method may not be regarded as excessive.

It does not seem safe to say more at present than that the value of V very probably lies somewhere between 18 km. and 21 km.

Reality of the Acceleration.

This phenomenon of acceleration in the velocities for successive types arranged in the now generally accepted order of development has come to the notice of astronomers in persuasive form rather suddenly, and consideration of it will need much extension and ripening before we may venture with much profit upon hypothesis. About the reality of this progressive velocity there can be no doubt. When we seek stellar velocities in terms of the solar velocity V without converting the latter into units of terrestrial measurement, the ratio of $\tau_0'' : M$ within the respective type-groups is capable of being determined with a fair degree of confidence,— perhaps with quite as much as attaches to determinations of the relative values of ρ_0 in the various types. The determinations of τ_0 and ρ_0 are actually independent of each other; they differ, in that τ_0 is expressed in units of the total motion of the sun for the unit of time underlying τ_0'' and M, while ρ_0 is expressed in kilometers per second. Each shows the progression of velocity for types in the accepted order of evolution independently of each other; and in this sense they agree surprisingly well. The testimony is unmistakable, and the results for $\tau_0'' : M$ are not uncertain by any considerable proportions of their amounts.

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* If corrected for projection so that τ_0 corresponds to the hypothetical mean for the entire sphere like τ_0 for following types this becomes approximately 6.6 km. (See *ante* p. 192.)

† CAMPBELL's determinations of mean ρ_0 are to be found in the *Publications of the Astronomical Society of the Pacific*, Vol. XXII, p. 238. His limits for *B* include B_8 and B_9 and for *A*, *A* to A_8.

‡ See paper of KAPTEYN and FROST, *Astrophysical Journal* for July, 1910, p. 83. Taking out B_8 and B_9, 51 remaining stars reduced to $V = 20$ km. give 6.8 km. (See *ante* p. 192).

** From an unpublished paper by FROST read at a meeting of the National Academy of Sciences, November, 1910, kindly communicated to me by Professor FROST. Discarding Companion of a double star and reducing to $V = 20$ km. I find ρ_0 for 31 stars of type *A*, 10.4 km.

Relation of Type to Distribution in Galactic Latitude.

Another phenomenon should be recalled in regard to these accelerating velocities. It is known that stars of types *B* and *A* form a larger proportion of the stars near the Milky Way than they do elsewhere. It will probably be found that this arrangement is equally or more emphasized for the fainter and more distant stars. In this paper we have only to do with stars down to H.R.P. $6^{M}.5$, and only with a part of the stars down to that magnitude when they are fainter than H.R.P. $5^{M}.7$. Table IV shows an enumeration of these stars arranged by types and in Galactic zones 20° broad. After the zones $+10°$ to $-10°$ the others contain one-half the sum of the two corresponding zones, $+10°$ to $+30°$ and $-10°$ to $-30°$, and so on.

TABLE IV. ENUMERATION OF TYPES IN GALACTIC ZONES.

Zone	Limits	*B*	*A*	*F*	*G*	*K*	*M*
I	+10° to −10°	237	422	142	103	237	33
II	±10 to ±30	105	310	104	63	205	34
III	±30 to ±50	14	170	89	66	155	31
IV	±50 to ±70	5	100	51	30	102	24
V	±70 to ±90	2	32	13	12	32	5

TABLE V. TABLE OF RELATIVE AREAL DENSITIES IN PERCENTAGES.

	Limits	*B*	*A*	*F*	*GKM*
I	+10° to −10°	100	100	100	100
II	±10 to ±30	47	78	78	87
III	±30 to ±50	7	53	82	88
IV	±50 to ±70	5	47	72	84
V	±70 to ±90	5	44	53	76

In order to gain a clearer view of the arrangement we take the unit of areal density in each type to be that of the first zone in that type ($+10°$ to $-10°$). Thus with type *B* as an example, in Table IV, we have 237 stars in zone I. If stars are distributed to the same areal density in zone II as in I we should have 223 in the former; we actually have 105. Therefore the areal density for zone II is 47 per cent. Table V gives the percentage of areal density in zonal relations for each type. The areal density in distribution of *M* stars is actually less in the Milky Way than it is at latitude $+20°$ and still less than it is at 40° of latitude. But as there are only 222 stars in that group I combine them with groups *G* and *K* into one.

For the older types the decrease of areal density with increase of latitude is not very marked; very probably not much more marked than might be due to greater depth of volume in the direction of the Milky Way. The areal density for type B begins falling off very decidedly in zone II, where it is about one-half what it is in zone I. In respect to distribution on the face of the sky the contrast between stars of the *B* type and those of the older types is very striking — the distribution of the former being very uneven. The law of distribution of stars of type *A* is almost exactly intermediate between that of *B* and that of the older types (Tables IV and V). The progression in the character of the arrangement of areal density can be noticed even in the case of type *F* situated between type *A*, on the one side, and the older types on the other, as shown in Table V. The relative areal density at the pole for the stars of the *F* type is clearly greater than for the *A* type and less than for the *K* and later types.

This leads one to suspect that the reason we see a smaller proportion of first type stars in high latitudes than in low latitudes is that the stars may originate relatively not far from the present median Galactic plane and that a large proportion of the stars of types *B* and *A* become, by evolution, second type stars before they reach by their motions great distances from the median plane and in relations to give them, at the same time, high latitudes.

Special Remarks on Stars of Type B.

It has already been remarked that a comparatively large volume of space near the sun seems to be substantially devoid of Helium stars. I should estimate the outer boundary of this space to be roughly two-thirds the harmonic mean distance of all the stars, other than those of type *B*, that have proper-motions less than 20″ per century. This would correspond roughly to 15 Sirian-distances, or to an annual parallax of about ″.015.

At present the sun's position within this space does not seem excessively eccentric. In and about the constellations *Centaurus* and *Scorpio* (12^{h} to 19^{h}) about 100 of the 490 *B* stars contained in this discussion are situated. These appear, to be in the mean, sensibly nearer the sun than the average distances of *B* stars situated elsewhere in the sky. These 100 stars are all fairly near the parallactic equator, at distances mostly 60° either from the Apex or Antapex. The mean distance of *B* stars situated within 30° from either of those points seems to be rather greater than the mean for the stars described. The natural inference seems to be that few new stars are now forming in this open space and that, if at any time it is to be filled up with *B* stars from the outside, only those stars of that type whose motions are converging in a general way upon that space will be efficacious for the purpose. If we suppose that this process has been already going on for some time then the more rapidly moving *B* stars whose motions are directed in a general way toward the point where the sun now is would have outstripped their slower companions and this would have led to a preponderance of negative values of ρ for the *B* stars nearest the sun. The direct contrary appears to be the case with *B* stars in general. Only 17 of the 61 values of ρ for *B* stars contained in FROST's tables (*Ap. J.* Vol. 32, p. 84) are negative.

Owing to this prevalence of positive values of ρ from *B* stars, Kapteyn and Frost find from *B* stars (*Ap. J.* Vol. 32, p. 87)

For V around Apex, -18.38 km.
For V around Antapex, -28.38 km.

Speculative suggestions of explanation for this are attended with great difficulties in their details. It would seem desirable to await further data of observation. Of the 33 values of ρ for *A* stars, kindly communicated to me by Professor Frost, 14 are positive and 19 negative. The preponderance of positive signs exhibited by the *B* stars is not shown with these few *A* stars, but there is actually an excess of negative signs. The number of stars, however, is too small to allow this preponderance to have any special significance. The places on the sky of only 6 stars of Frost's 33 of type *A* are at a distance from either Apex of less than 40°. Considering the difficulties of measurement, among which are certain doubts about the standards of wave-length (see Frost *Ap. J.*, Vol. 31, p. 430) and the complicated details in accounting for a notable excess in positive values of ρ for *B* stars, it seems rather venturesome to suggest that the brighter stars of *B*-type are actually, to a preponderant extent, moving away from the sun. If they are doing so the anomaly found by Kapteyn and Frost in determining V might be accounted for.

On the Accelerating Force—Difficulties.

To inquire seriously into the cause of the accelerations of velocities that appear to increase with the evolution of stellar types is no part of my purpose. To pass beyond a very vague sort of speculation at the present time seems to me quite hopeless. But it may be worth while to examine in a superficial way some of the difficulties to be encountered in the attempt to frame hypotheses.

If we suppose that the stars have been formed from nebulous matter, with nuclei as effective starting points, it is not difficult to see that in a cluster of forming suns a vast amount of energy might be generated from the action of gravitation showing itself in the form of heat, rotation, orbital motion, etc. Under conceivable circumstances this energy, for some of the stars at least, might ultimately issue in sensibly linear motion, the product of hyperbolic motion or otherwise. The mutual approach, or collision, of stars in space may modify, through the action of mutual gravitation, motions already existing. A sensible preponderance of gravitational attractions from bodies in a given part of space acting upon a given body may accelerate, or retard, its motion. But the facts developed in the foregoing discussion of stars in types raise a new problem.

There can scarcely be a doubt that the same stars that are now seen as of the spetral type *A* were in past ages of the spectral type *B*, and then had a mean velocity of approximately only two-thirds, or three-fourths that which they have at present. It seems equally probable that *A* stars of the present will eventually become stars of the second type in the future and along with that physical development will acquire an increase of mean velocity about 50 per cent. greater than those stars now have. This fundamental fact of acceleration in the means of the stellar motions must have a vital bearing on questions of stellar development. Gravitation can accomplish much in accelerating or retarding the motions of a star, or in altering its direction, so long as it does not have to discriminate in regard to the physical conditions of a star upon which it acts. It is difficult to see how gravitation alone can have produced a general acceleration in the mean velocities of stars at successive stages of evolution, and then at a certain stage of that evolution cease to produce futher sensible action of that kind. At the present time the stars of all the types later than *B* are fairly well intermingled in space. The mean secular parallax, *M*, of the *A* stars employed in this paper has been shown to be 4″.08, and of the combined types, *F*, *G*, *K* and *M* is 3″.93. That of *K* alone is 4″.03. The stars of these types being very well intermingled on the whole, any star of a given type among them must be subjected to the same general attractions of gravitation as its immediate neighbors of other types. It is an absolutely logical inference that the existing stars of type *A*, in accordance with what seems to be an orderly evolution will continue to be acted upon by some form of energy tending to accelerate their motions until they shall have developed into an older type; while it seems to be an equally irresistible inference that no such action will take place upon their immediate neighbors which are now of type *G* and later. Yet both *A* and *G* stars have been in general subjected to practically the same gravitational action. We seem then to be driven to the conclusion that this accelerating force is something other than what we know as gravitation. We must look elsewhere for a force that is selective in its action — the selection being dependent on physical condition.

There are forces other than gravitation acting through interplanetary space — perhaps through interstellar space, though it would seemingly be fruitless at the present time to attempt to identify one of them as the efficient cause needed. Among other forms of force that might be useful in the present contingency is radio-active energy. We would naturally look for the manifestation of such forces in the early stages of world-evolution. The prominence of Helium (a known product of radio-active phenomena) in the spectra of stars of type *B* (Helium Stars) may be an indication. We quite certainly know that electromagnetic action is generated in the sun. It would be natural to infer that this action was relatively more important and efficient in the earlier history of that body, and in others like it, than it is now. That something equivalent in effect to a repulsive force emanating from the sun operates upon matter forming the tails of comets is quite certain. It is almost certain that the velocities imparted to matter in the tail vary with its physical condition. This action has no perceptible effect on the nuclei of comets; may not be sufficient to overcome gravitation in the rare type of tails that are shortest and most curved; and may be over 10 times the force of gravitation upon the long and nearly straight tails sometimes developed. Much experimental and mathematical research has, of late years, been devoted to forms of energy associated with the hypothesis of electro-magnetic action in relation to light.

As a matter of mere convenience in speculation it has, for a long time, seemed more natural to think of the generation of stars as originating in vast nebulas; consequently developing in clusters; and of the stars diffusing from those clusters into surrounding space. The first part of this suggestion is called to mind by the clustering tendencies of stars in the direction of the Milky Way. If these clusters are being dispersed by the mutual action of repulsive forces acting from within the clusters, sending off the outside stars first, under the law of equality of action and reaction, we should expect the distribution of proper-motions generated by such an agency to be approximately random in direction, or at least symmetrical about the origin, even if the motions in a given direction, from some effect of polarity, should have a tendency to be greater in certain directions. It seems probable that the stars in the Milky Way, and in its direction, are more thickly crowded in areal density not so much because we see through greater depth of space filled with stars at approximately uniform volumetric distribution, but more especially because the stars are more thickly crowded together in volume. This has been forcibly put by Professor HUGO SEELIGER in the summary of a very thorough and able examination of this subject, based upon counts of the Durchmusterung's, supplemented by the results of star-gauges. He says:

"Indessen kann man sich doch auch jetz schon nicht ohne Berechtigung ein algemeine Bild von Wesen der Milchstrasse machen. Diese befindet sich in einer Gegend der Fixternsystems, wo die einzelnen Weltkörper in grösserer Nähe bei einander stehen, als anderswo. Hier werden nun die Anziehungs-Kräfte zwischen den einzeln Welt-Körpern eine grössere Rolle spielen können, als in andern theilen des Systems, in welchen die Materie überaus sparlich verstreut ist." (*Kön. Bay. Akad. der Wiss.*, *Math. Phys. Klasse*, *Band* 19, *s*,570 629). This statement would equally apply if for "*Anziehungs*-Kräfte," we substitute "some form of repulsive force."

But the idea of a dominant repulsive force in this connection is not to be lightly accepted, even though gravitational force seems to be inadequate to produce acceleration of the kind required. In the first place there is the stability of probably gaseous bodies themselves to be considered. Secondly it is known that a large percentage of the younger stars are spectroscopic binaries of very short periods and approximately circular orbits in the very newest. Within those systems the action of an attractive force seems to be especially revealed. We are involuntarily led to imagine the existence of some form of force with arrangements of polarity by which it may act upon systems as units in one way and within systems in another.

These difficulties, however, need not and scarcely can impair our conviction that in some way the sensibly rectilinear motions of stars experience a well-marked acceleration while those stars are passing through the early stages of their physical development; and the force that produces this effect is selective as to the physical condition of the bodies upon which it acts.

The number of stars here considered is barely sufficient to indicate qualitative results. We must have a very much greater number of well determined motions, before we can hope to examine with much prospect of success many problems connected with this research, or before we can obtain much more satisfactory quantitative results.

EPHEMERIS OF MINOR PLANET *HUNGARIA* (434),

BY JOHN M. POOR.

The following ephemeris of *Hungaria* for the opposition of 1911 has been computed from elements given in *Berliner Jahrbuch* for 1912, without correction for perturbations. According to the computation opposition occurs April 27 and the magnitude is 11.8.

Precession since 1855 of the mean positions of the planet is as follows —

March 28 , $\Delta\alpha = +2^{m}\ 47^{s}$, $\Delta\delta = -14'\ 33''$
April 29 , $\Delta\alpha = +2\ \ 40$, $\Delta\delta = -15\ \ 37$
May 31 , $\Delta\alpha = +2\ \ 39$, $\Delta\delta = -16\ \ 26$

A change in the mean anomaly of +30′ would cause changes in the apparent position of the planet as follows:

March 28 , $\Delta\alpha = +3.7^{m}$, $\Delta\delta = -2.9'$
April 29 , $\Delta\alpha = +4.2$, $\Delta\delta = -0.4$
May 31 , $\Delta\alpha = +3.5$, $\Delta\delta = +5.0$

The apparent positions are given for each Berlin mean midnight.

Berlin 12h 1911	App. R.A. h m s	App. Decl. ° ′ ″	log r	log Δ
Mar. 28	14 37 13.9	+ 5 26 59	0.2892	0.0151
Apr. 1	35 48.9	7 0 16	0.2884	0.0068
5	33 52.9	8 34 13	0.2876	0.0000
9	31 29.4	10 7 23	0.2868	9.9947
13	28 41.6	11 38 15	0.2860	9.9910
17	25 34.0	13 5 21	0.2851	9.9890
21	22 11.4	14 27 11	0.2843	9.9886
25	18 39.2	15 42 30	0.2835	9.9899
29	15 4.3	16 50 8	0.2827	9.9927
May 3	11 33.0	17 49 16	0.2818	9.9970
7	8 41.3	18 39 22	0.2810	0.0026
11	5 4.8	19 20 14	0.2802	0.0092
15	2 17.9	19 51 56	0.2794	0.0169
19	13 59 54.3	20 14 42	0.2786	0.0253
23	57 57.3	20 28 53	0.2778	0.0345
27	56 29.4	20 34 57	0.2770	0.0441
31	55 32.0	20 33 27	0.2762	0.0542

Shattuck Observatory, Hanover, N.H.

ELEMENTS AND EPHEMERIS OF PLANET 1910 JJ,

BY ARTHUR SNOW.

This planet was discovered by J. H. METCALF, and from photographic observations made by him at Taunton, Mass., on Jan. 10, Feb. 1, and Mar. 4, 1910, the following elements were computed:

EPOCH 1910, FEB. 1.5, G.M.T.

$$\begin{array}{rl} M = & 54^\circ\ 45'\ 10''.8 \\ \omega = & 94\ \ 56\ \ 13.2 \\ \Omega = & 302\ \ 57\ \ 52.3 \\ i = & 12\ \ 53\ \ \ 1.7 \end{array} \left.\vphantom{\begin{array}{l}a\\a\\a\end{array}}\right\} 1911.0$$

$$\begin{array}{rl} \varphi = & 13\ \ 56\ \ \ 7.4 \\ \mu = & 621''.9100 \\ \log a = & 0.504186 \end{array}$$

RESIDUALS (O−C).

1910	$\Delta\alpha$ s	$\Delta\delta$ ″
Jan. 10	+0.01	+0.2
Feb. 1	−0.05	+0.3
Mar. 4	−0.02	+0.4

HELIOCENTRIC COORDINATES 1911.0.

$$x = [9.992263]\, r \sin (128^\circ\ 34'\ 19''.0 + v)$$
$$y = [9.937748]\, r \sin (\ 32\ \ 16\ \ 19.9 + v)$$
$$z = [9.726847]\, r \sin (\ 56\ \ \ 9\ \ 41.8 + v)$$

OPPOSITION EPHEMERIS.

1911 G.M.T.	α (1911.0) h m s	δ (1911.0) ° ′	log Δ
Feb. 23.5	12 3 49	−15 39.3	0.45567
27.5	12 1 15	15 37.8	0.45188
Mar. 3.5	11 58 31	15 33.8	0.44872
7.5	11 55 38	15 27.5	0.44619
11.5	11 52 39	15 19.0	0.44433
15.5	11 49 36	15 8.4	0.44320
19.5	11 46 32	14 55.9	0.44284
23.5	11 43 29	14 41.6	0.44322
27.5	11 40 29	14 25.8	0.44431
31.5	11 37 35	14 8.9	0.44615
Apr. 4.5	11 34 50	13 51.0	0.44870
8.5	11 32 15	13 32.5	0.45193
12.5	11 29 51	13 13.8	0.45578
16.5	11 27 41	12 55.1	0.46025
20.5	11 25 46	−12 36.6	0.46525

Opposition in R.A., March 17, 1911. Magn. $14^{M}.0$. ± 1^{m} in R.A. = ±8′ in Decl.

NOTICE.

The *Astronomical Journal* consists of 24 eight-page numbers, with table of contents and index. The present number completes Volume XXVI. Volume XXVII will begin with the next number, 625. Subscriptions are five dollars the volume, payable in advance. Postage is prepaid by the publisher. All communications and remittances should be addressed to the undersigned, *Editor of the Astronomical Journal, Dudley Observatory, Albany, N.Y., U.S.A.* Subscribers are requested to promptly notify the editor of any error, or desired amendment, in the address of the copies sent to them. Back numbers, or volumes for completion of sets, are supplied at rates which are stated in a *Circular of Information* which will be sent on application. LEWIS BOSS, *Editor.*

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